EFFICIENCY TESTS OF A SMALL REFRIGERATING MACHINE

BY

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ARMOUR INSTITUTE OF TECHNOLOGY

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EFFICIENCY AND CAPACITY TESTS OF A SMALL ABSORPTION REFRIGERATING MACHINE

A THESIS

PRESENTED BY

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TO THE

PRESIDENT AND FACULTY

OF

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They also wish to express their thanks and appreciation for the help received from the various Shop Instructors and Assistants.

Herbert P. Sherwood.
Jee Kwun Wong
Jess A. Ager

OCT 11

PREFACE

The object of this thesis is the determination of the efficiency, and capacity of a small absorption refrigerating machine, at various rates of refrigeration.

This machine is a recent invention, the patents having been issued in December of 1914. It is manufactured for the Autovacuum Refrigerating Company of Louisiana.

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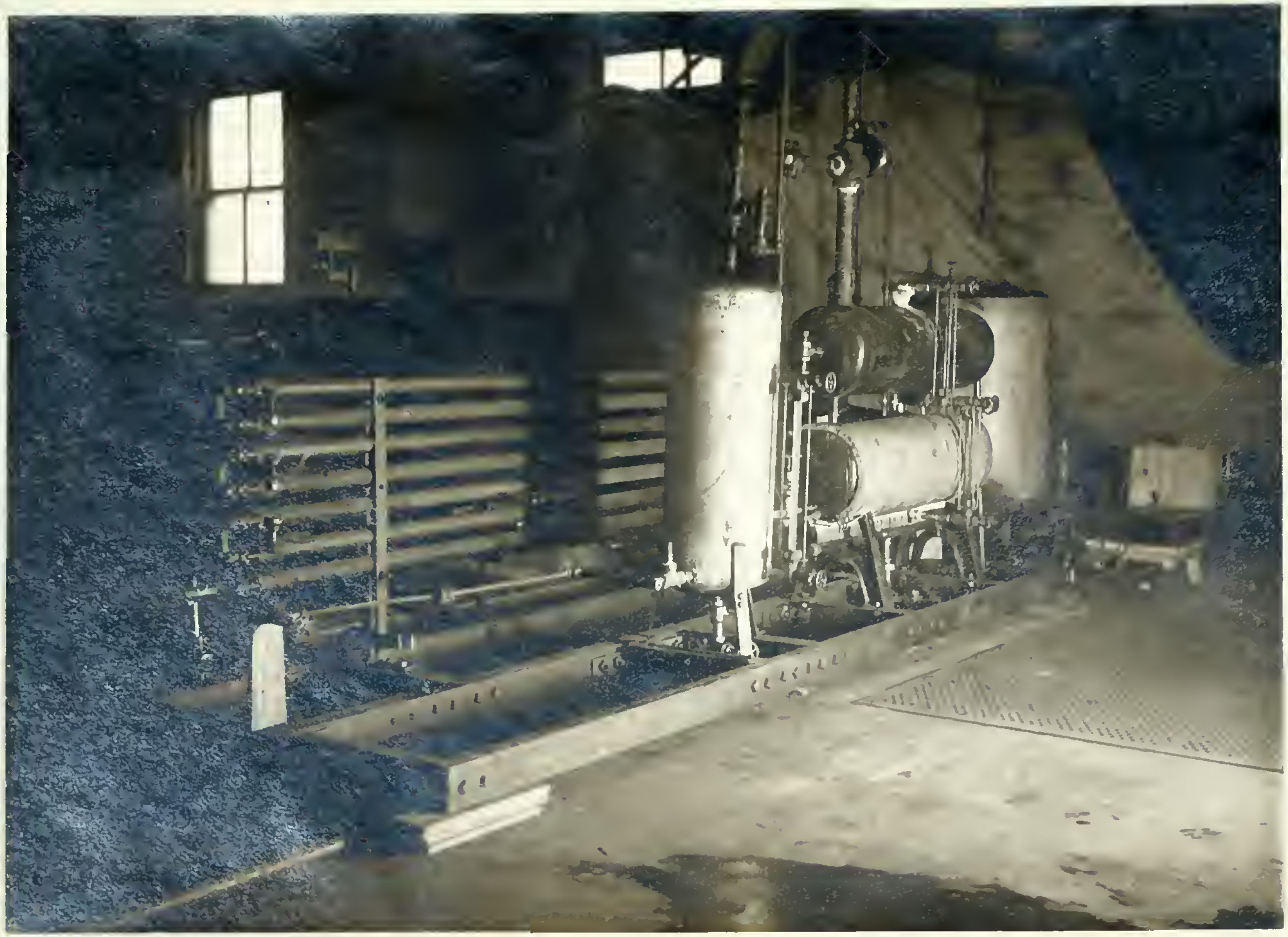
PART 1.

DESCRIPTION OF APPARATUS

DESCRIPTION OF APPARATUS

The apparatus and connections are shown in the diagrammatic outline in Figure 1.

The machine consists of a combined generator and absorber composed of two horizontal tanks "AA", shown in Figure 1. These are connected by two pipes, a short one "A" called the upflow, and the other "B" called the down-flow. The down-flow pipe reaches almost to the bottom of the lower tank. The circulation of the liquor takes place through these pipes between the tanks. There is a twelve inch gauge glass "C" on each tank. The upper tank contains a cooling coil in which the cold water is circulated. The flow of water is regulated by valve "M". The return flow from the refrigerator enters the lower tank close under the down-flow pipe. A large pipe "F" leads from the top of the generator and connects to the line into the condenser. This pipe "F" acts as a dehydrator or rectifier, the function of which is to separate entrained water from ammonia gas.



through expansion valve "E" to the refrigerating coils "J". The return line from the refrigerating coils leads through the return valve "R" into the lower tank. A sampling valve "T" is placed in the return line between the return valve and the generator.

A gas burner "L" is placed under the generator with a meter in the gas line for measuring the quantity of gas consumed.

The water lines from the generator and receiver are run to separate weighing tanks. Thermometer cups are placed in the lines for measuring the temperature of inlet and outlet cooling water.

The refrigerating coils are double pipe coils in which ammonia expands in the inside coil,, and brine is circulated through the outside coil. The brine is drawn from the sump by a small motor driven centrifugal pump. The pump delivers the brine into a reservoir tank on the floor level and from there to a small tank about six feet above the top of the

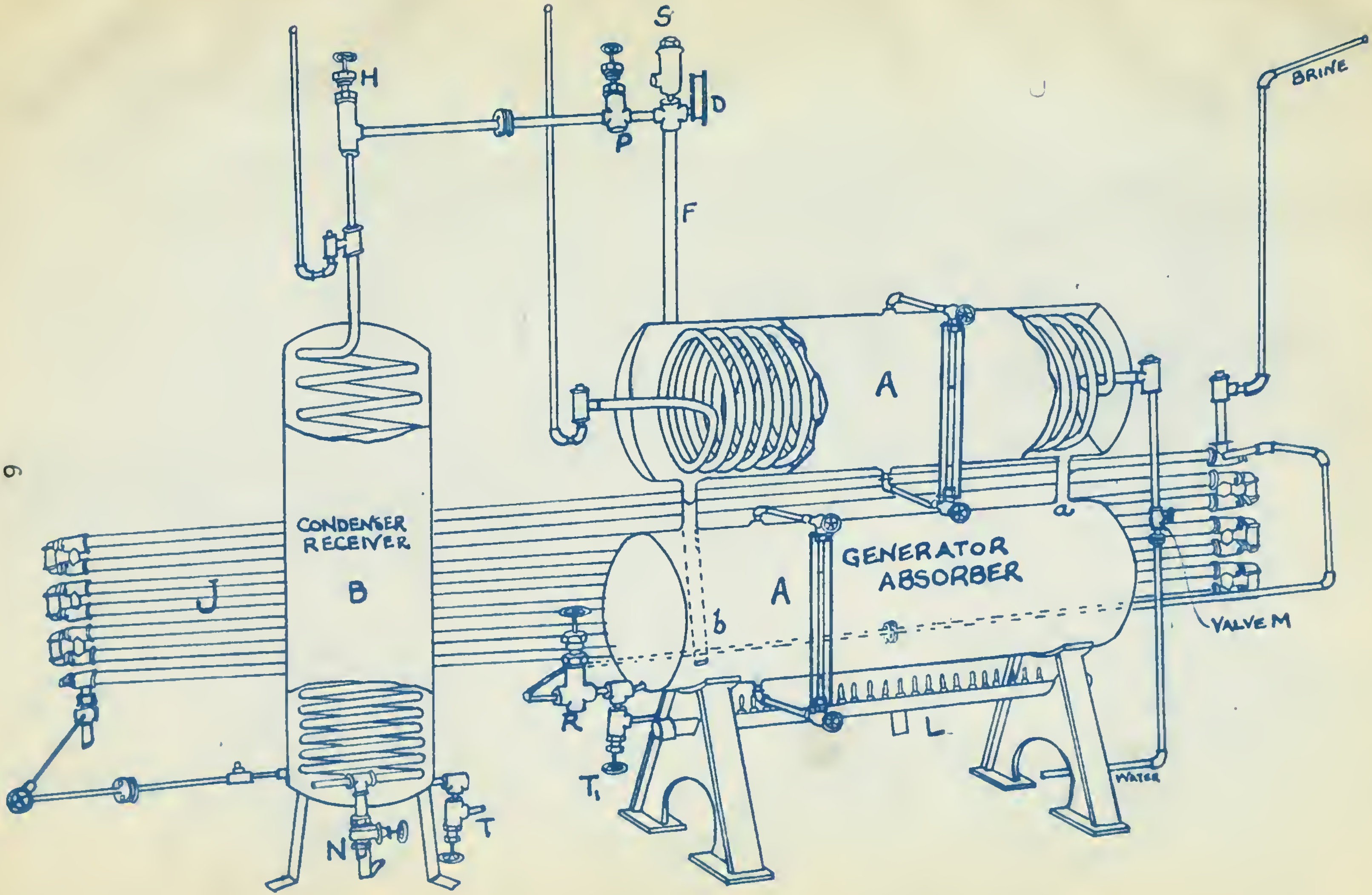
A large cross-fitting provides connection for the ammonia pressure and vacuum gauge "D", and for safety valve "S", and for purge valve "P".

The line from the dehydrator leads through stop-valve "H" to the combined condenser and receiver "B".

The combined condenser and received "B" is a vertical tabk having a double coil running through it; a one-half inch pipe coil inside of a one-inch pipe. The two coils have separate end connections. The outside coil is for water and the flow is regulated by valve "N". The one-half inch coil is for the ammonia, the coil ending in the tank.

At the bottom of the tank two ammonia outlets are provided, one outlet for the line connecting to the refrigerating coils, and a small opening for the sampling valve "T.". The receiver is fitted with a twenty inch gauge glass.

The ammonia line leads from the receiver "B"



DIAGRAMMATIC OUTLINE OF MACHINE AND COILS

FIG. I

H. P. Sherwood
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brine coils. This tank is provided with an overflow so that there is always a constant head on the brine flowing from this tank through the brine coils. Thermometer cups are placed in the brine line close to the coils for obtaining the temperature of the brine entering and leaving the expansion coils. To prevent loss of refrigeration by radiation, conduction, etc., the expansion coils are encased in a wooden box and packed with granulated cork for a distance of six inches on each side of the coils and six inches at the ends.

PART 2.

INSTALLATION

INSTALLATION

The base of the machine is built of four-inch channel iron, and four-inch eye-beams. The two sides, and the two ends, are channel-irons, the flanges being sawed off to allow the web to fit into the side pieces. A four-inch eye-beam is located centrally between the two sides, running lengthwise. The flanges are cut off of this piece to allow the web to fit into the ends. There are six short eye-beams, perpendicular to the long side, between the sides and central eye-beam. These short pieces support the coils, the receiver and condenser, and the absorber and generator. The entire base is held together with angle irons and bolts. Provision has been made (at the four corners of the base) for castors, so that the apparatus may be moved with little inconvenience.

The legs of the absorber are made of cast iron, and when received from the manufacturer, the webb was so high that the gas burner would not fit under the absorber and generator. It was therefore necessary to saw some of this web

out, and to compensate for the strength lost in its removal, a steel band was fitted over the top of each leg, being fastened thereto by small bolts.

The legs are secured to the base by bolts; holes for these bolts being drilled through the base of the legs, and corresponding holes through the flanges of the eye-beams.

A three-legged frame was made for supporting the receiver. This frame is also bolted to the base.

The double pipe coils are supported by four iron strips, having a right angle bend at the bottom for feet. These strips are bolted together in pairs on each side of the coils, the bolts supporting the coils. These supports are also bolted to the base.

The ammonia pipe connections between the different parts of the apparatus are extra heavy black pipe. Ammonia joints are used throughout. In order to insure pipe joints being tight a mixture of letharge and glycerine was used.

The relative position of coils, tanks, and the pipe connections are shown in the illustrations.

Thermometer cups are placed in the pipe lines at the following points:

Inlet to coils in brine line.

Outlet to coils in brine line.

Inlet to cooling water coil in absorber and generator.

Outlet to cooling water coil in absorber and generator.

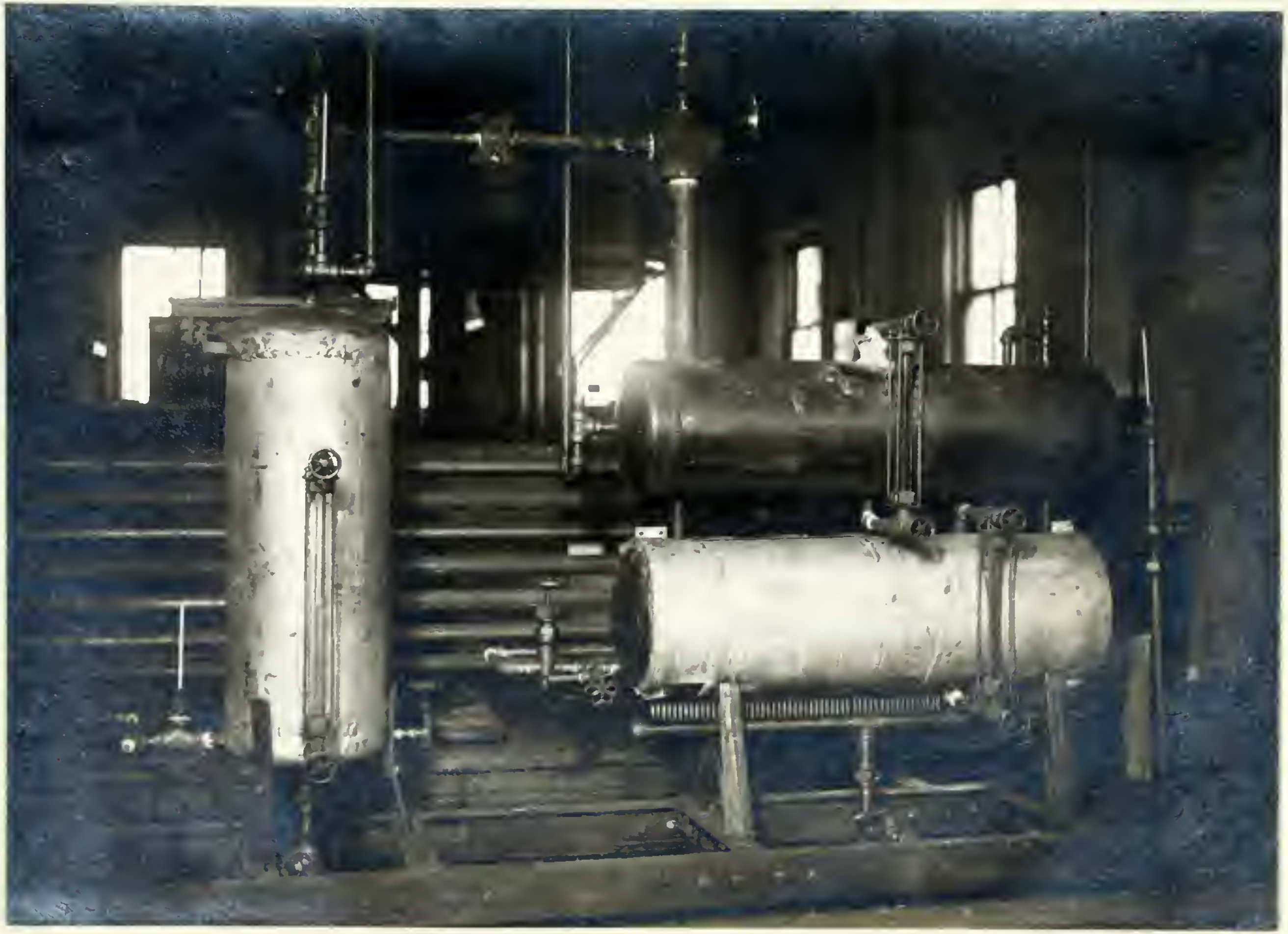
Inlet to cooling water coil in condenser,

Outlet to cooling water coil in condenser.

Outlet from condenser in anhydrous ammonia line.

The illuminating gas line is made up of one inch gas pipe, and is run under the base of the machine, coming up to the gas burner which is fastened to the legs of the absorber and generator.

The cooling water line is made up of three-quarter inch pipe, and is also run under



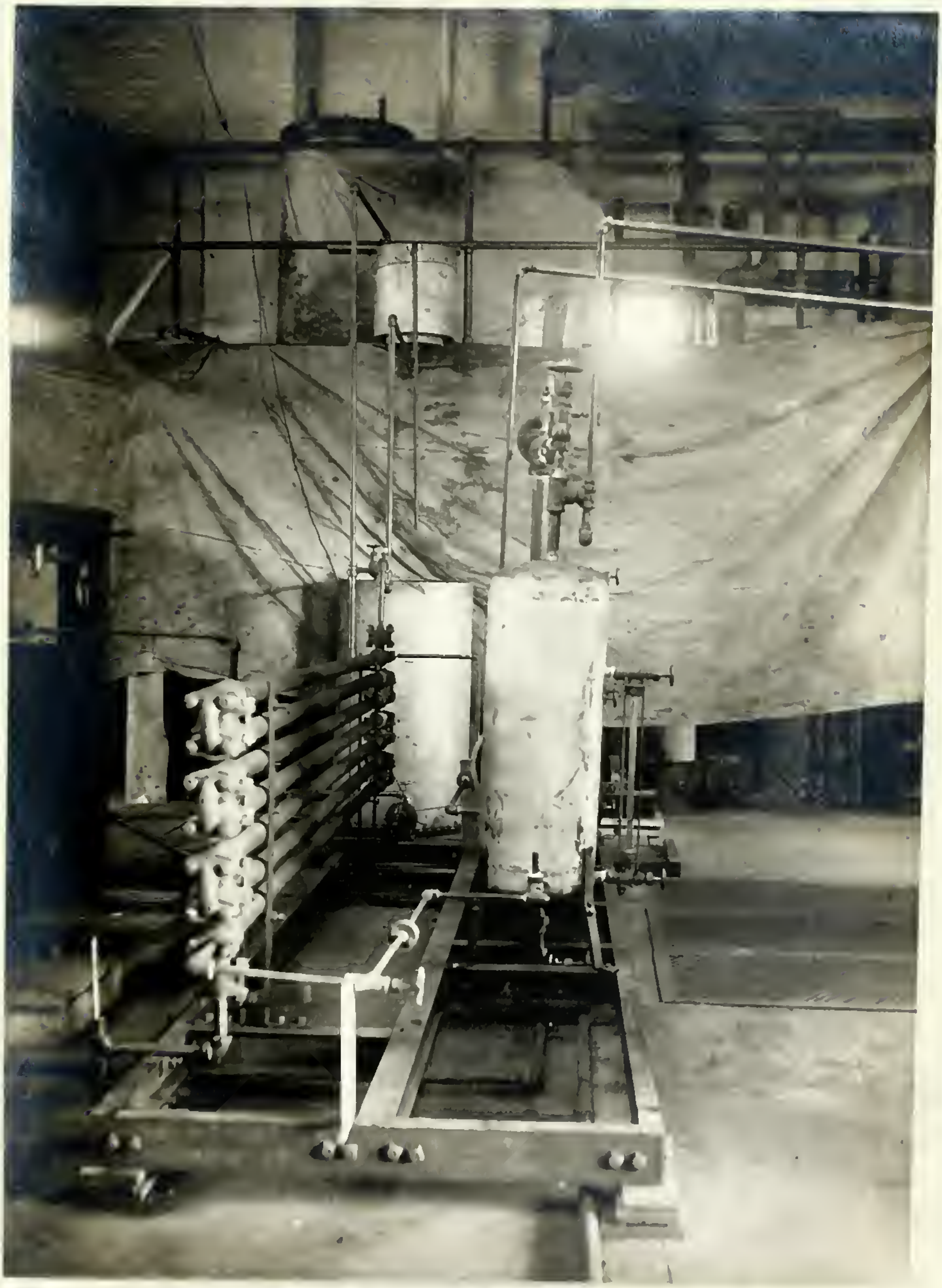
the base of the machine. One branch of this line feeds the water coil in the condenser and the other feeds the water coil in the absorber and generator. The outlets from these two coils are piped to weighing tanks.

PART 3.

METHOD OF OPERATION

METHOD OF OPERATION

The operation can be divided into three periods; first "boiling off", second "cooling", third "expanding and absorbing". "Boiling off" consists of heating and driving off the ammonia gas from the strong liquor in the generator, and of cooling and condensing the gas in the combined condenser and receiver. When the pressure rises to fifty pounds the valve in the line to the condenser is cracked, and at one hundred pounds the cooling water is turned into the condenser after which the ammonia valve is gradually opened full. The ammonia gas is boiled off until the water level in the upper tank drops to one inch in the gauge glass. The pressure rises during this time until it reaches one hundred and fifty pounds, or to a higher pressure depending on the rate of flow and temperature of the cooling water. At the beginning of the boiling off the purge valve is opened slightly to allow any entrained air



and accumulated gas to escape.

As soon as the gas has been boiled off the stop-valve at the receiver is closed, and water is turned into the cooling coil in the upper tank. The weak liquor is cooled down until the ammonia vapor and water vapor in the upper tank is condensed and forms a vacuum in the generator. The vacuum formed is very close to perfect, realizing a little better than twenty nine inches of mercury.

The machine is then ready to produce refrigeration. The valve in the return line from the refrigeration coils is opened and the expansion valve is cracked, allowing the liquid ammonia in the receiver to expand from the pressure in the receiver through the expansion coils back to the vacuum in the generator which now performs the duty of an absorber. The vacuum in the absorber helps pull the ammonia through the coils and the weak liquor absorbs the ammonia gas as fast as it returns.

PART 4.

TESTING OF APPARATUS

PRELIMINARY TESTS

After installing the machine it was necessary to test for leaks before putting in the ammonia. Several gallons of water were put in the generator, and heated up to a steam pressure of two hundred pounds. This is about the maximum pressure to which the pipe joints and connections are subjected. As there were no leaks developed under this pressure, the water was blown out of the machine by its own pressure through the sampling valve. A vacuum was established by condensing the steam remaining in the generator. The generator was filled with about thirty three gallons aqua ammonia, using the vacuum to draw the ammonia from the carboys.

Several samples of the aqua ammonia were tested, and the strength was close to twenty nine degrees Baume. For best operation the strength should be between twenty six and thirty degrees Baume, so that the ammonia used was well above the required strength.

The calcium chloride brine was tested and found to be eighty four degrees Salometer. This corresponds to a specific gravity of 1.167. The specific heat of calcium chloride brine of specific gravity 1.167 is given in Siebel's Compend of Refrigeration as 0.766, and the freezing point -.84 degrees Fahrenheit. The inlet and outlet brine thermometers were compared and found to read the same within a small fraction of a degree, that is, within the limits of error of other measurements.

Before the ammonia gauge was installed on the machine, it was calibrated throughout its range on both the pressure and vacuum readings. The calibration curves are given in Part 7.

REFRIGERATION TESTS

A test was made before insulating the expansion coils, and four tests were made for the insulation on the coils. An economy test was run, taking the amount of gas and the amount of cooling water used for "boiling off".

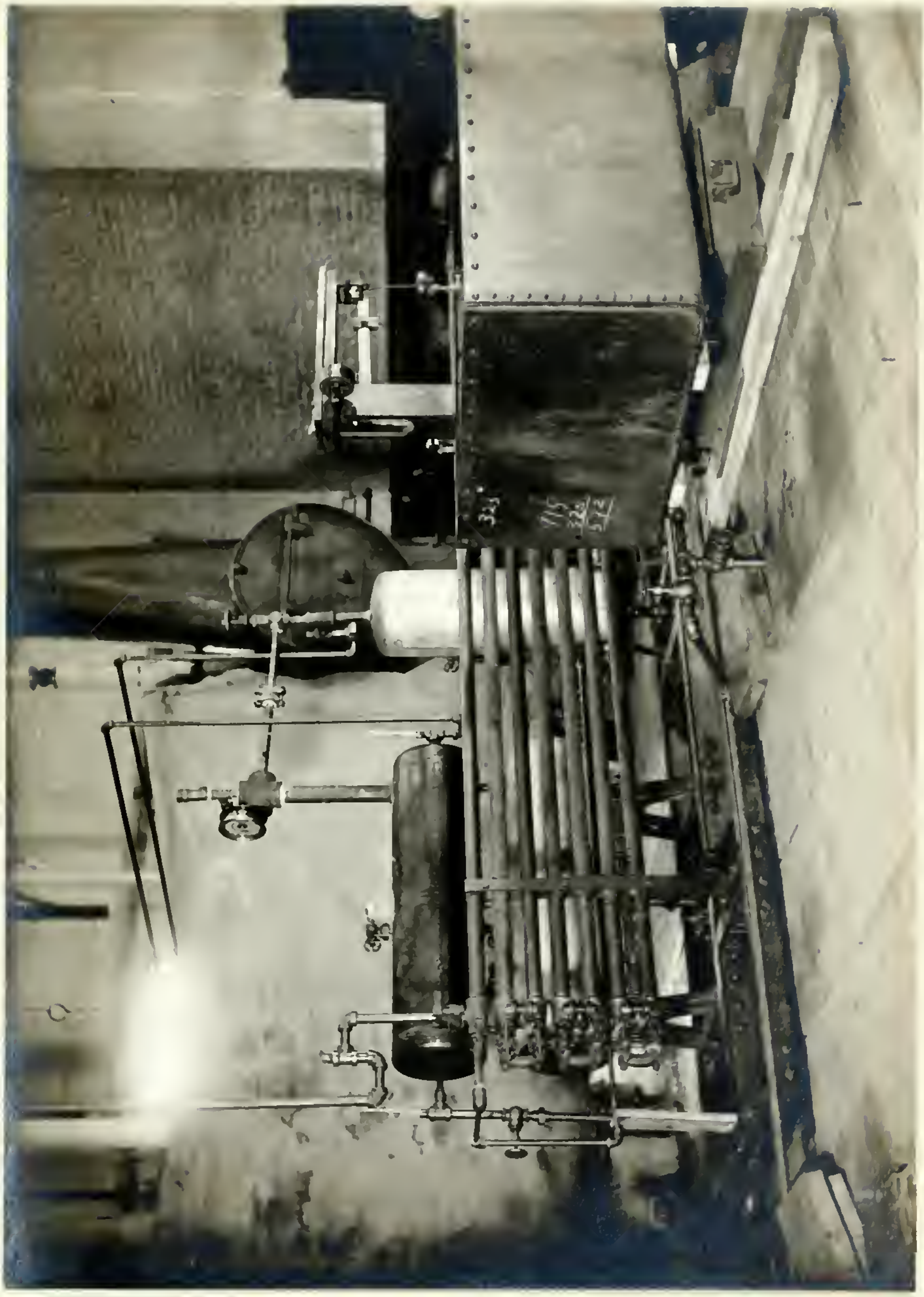
The first test was of two hours and fifteen minutes duration. The rate of flow of brine was kept constant and the opening of the expansion valve was varied to keep the temperature of the brine above the freezing point. At the beginning of the run some of the cooling brine was lost from the weighing tanks through the valve to the sump leaking. The valve was taken off and pipe plugged up to prevent further loss.

The first run in which the expansion coils were insulated was of five hours and fifteen minutes duration. Brine froze in the coils after running about forty five minutes. The expansion valve was closed and a hydraulic pump was connected to the coils and brine was forced through to open up the pipes. The run proceeded as before with smaller opening of the expansion valve and practically the same rate of flow of brine, as in the first test without insulation.

Run No. 3 was of two hours and thirty-five minutes duration, with the expansion valve open three-quarters of a turn. The brine was regulated to keep the temperature as close to ten degrees Fahrenheit as possible. A sample of ammonia was drawn off during the run and was found to contain seventeen percent of water.

Run No. 4 was made with the expansion valve opened one full turn and the length of the run was two hours and three minutes. As in the previous runs, the brine was regulated to keep the temperature as near to ten degrees Fahrenheit as possible. Sample of ammonia showed sixteen percent water.

Run No. 5 was made to simulate actual conditions by expanding very slowly. The total length of run was twenty six hours and fifteen minutes. The expansion valve was opened about one-third of a turn, while the brine was regulated to keep the temperature close to thirty degrees Fahrenheit. Sample of ammonia showed thirty percent water.



The economy run was of three hours and twenty one minutes duration. The "boiling-off" was done very slowly on account of throttling of the supply of cooling water through the condenser.

PART 5.

DISCUSSION AND CONCLUSIONS

DISCUSSION AND CONCLUSIONS

The refrigeration was measured by the weight of brine flowing through the coils, and the drop in temperature between the inlet and outlet brine.

The heat absorbed from the brine by the ammonia is equal to:

$$W\ (t' - t'')\ S$$

where W- is the weight of brine.

S- is the specific heat of the brine.

t''-is the temperature of the brine leaving the coils.

t'-is the temperature of the brine entering the coils.

The refrigeration has been calculated as the equivalent ice melting capacity for the time consumed in making the run. Also the equivalent ice melting capacity per twenty-four hours, and the tonnage of the machine per twenty four hours. The equivalent ice melting capacity refers to the cooling effect produced by themelting of one pound of ice from and at 32 degrees Fahrenheit.

The container is alternately a generator and absorber; the advantage of this being economy of space and dispensation of expense for installing separate apparatus. It was found in the tests that the ammonia distilled contained too high a percentage of water. It is adviseable to put some baffle plates in the dehydrator so that when the moist ammonia vapor comes in contact with the baffles the moisture is caught and dropped back into the generator while the dry ammonia vapor is allowed to pass over to the condenser.

The strong liquor after doing its duty of refrigeration is discharges into the weak liquor line, continuous flow of which is kept up by a partial vacuum created in the absorber. The advantage of this system being the saving on the installation of an ammonia pump, as is necessary in all absorption machines.

In tests Nos. 1 and 2, it was shown that the loss of refrigeration in not providing proper insulation on the coils was nearly fifty percent.of that with insulation.

In the condenser the ammonia vapor is condensed on the counter current principle; by which the warmest ammonia vapor gives up its latent heat to the warmest water, and the coldest ammonia vapor to the coldest water. Under the influence of this counter current the ammonia liquor is cooled down more nearly to the temperature of the incoming cooling water. This method also affects the economy of the cooling water used as manifestly shown by the low cost of water for condensation in the economy run.

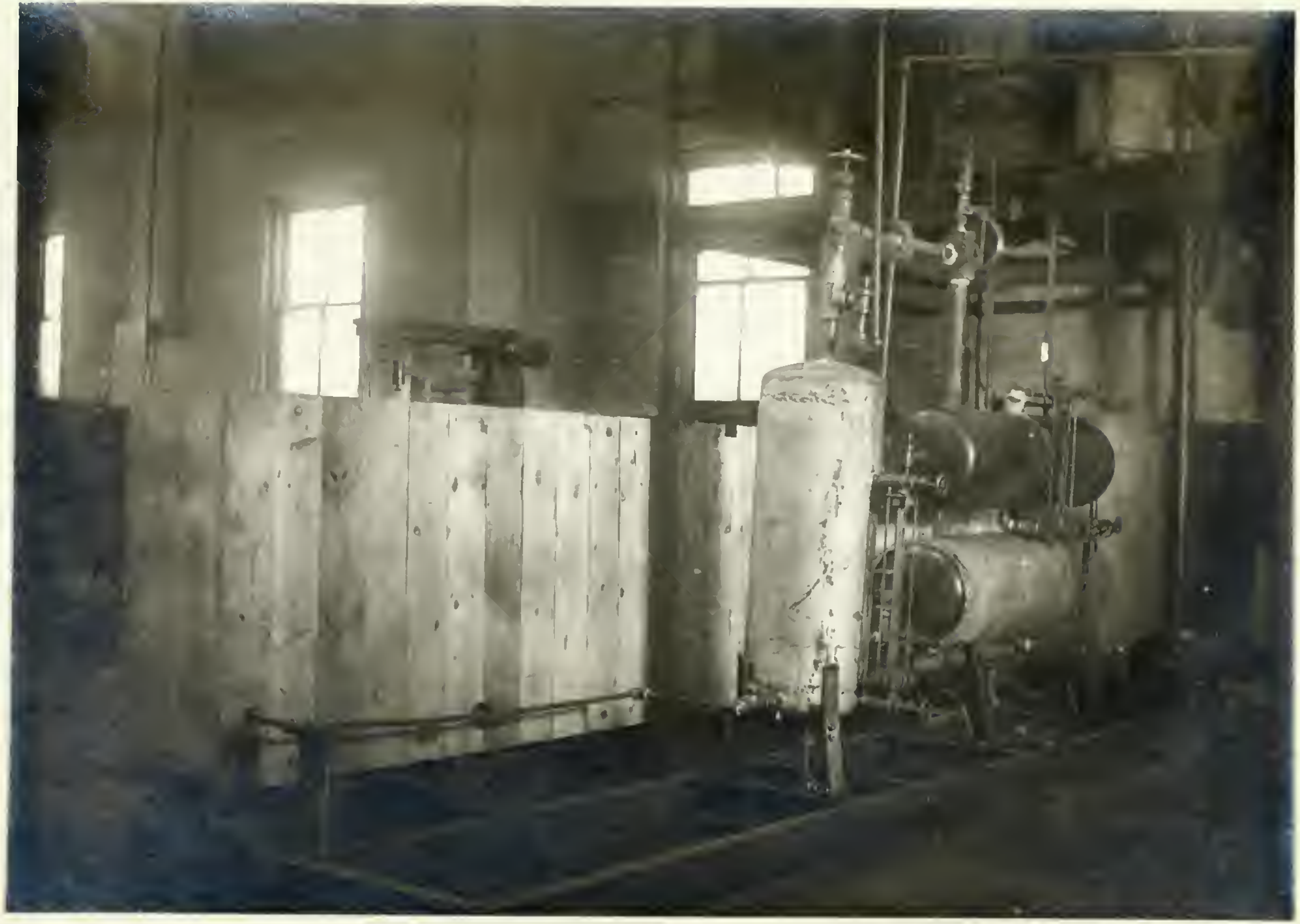
The special noteworthy feature of this machine is based on the small space requirements. It also has no moving parts and requires no motive power as in the compression machines. This means, of course, a saving in attendance as well as first cost. In boiling off, gas, gasoline, kerosine, steam, coal or wood, etc. may be used. This system offers safe and economical refrigeration for domestic refrigeration.

From the economy calculations it can at once be seen that the refrigeration machine is far more economical than the common method of cooling with ice.

Assuming that the machine is to be used in the city it is safe to say that the cost of ice per one hundred pounds will not exceed forty cents. Under the same conditions water will cost seven cents per one thousand gallons, and as the machine used 287.39 gallons the cost for the water would be $ .0201. Gas at the rate of eighty cents per one thousand cubic feet will cost the owner of a machine $ .2912, bringing the total cost of operation for the equivalent of one hundred and ninety pounds of ice up to $.3113.

It is evident that the cost for one hundred pounds will be $ .1599, and that a total saving will be made compared with that of purchasing an equivalent amount of ice at $ .40 per 100 pounds. The exact amount of the saving being equal to the cost of ice minus the cost of operation of the machine, or $ .40 - $ .1599 = $24.01.

Stated in this form the gain does not become so apparent as it does when stated in terms of percentage gained. The user of this machine will,save fifty percent of his money compared with buying the same amount of ice.



PART 6.

CALCULATIONS

TEST NO. 1

$B.T.U. = W(t' - t'')s$

347-332 (69-55) x .766
114.90

357.5-347 (64-44) x .766
161.26

Note: Outlet valve from weighing tank leaked letting brine flow away. Valve was removed and pipe capped.

371.5-360 (64-22) x .766
369.98

386-371.5 (64-17) x .766
522.03

400-386 (64-15) x .766
525.48

412.5-400 (64-12) x .766
497.90

425.5-412.5 (64-12) x .766
517.82

438.5-425.5 (64-10) x .766
537.73

451.5-438.5 (64-7.5) x .766
562.63

464.5-451.5 (64-7) x .766
567.61

476.5-464.5 (64.5-6.5) x .766
533.14

495-476.5 (64.5-6) x .766
829.04

513.5-495 (64.5-6) x .766
829.04

534-513.5 (64.5-6) x .766
927.09

551-534 (64.5-6.5) x .766
755.28

568.5-551 (64.5-7.5) x .766
764.09

583-568.5 (64.5-8) x .766
627.58

606-583 (64.5-8.5) x .766
986.61

612-606 (64.5-9) x .766
250.48

623.5-612 (64.5-8) x .766
497.75

637-623.5 (64.5-8) x .766
584.30

651-637 (65-8) x .766
600.54

664.5-651 (65-9) x .766
579.10

679.5-664.5 (65-12) x .766
608.98

TOTAL B.T.U.

13,750.36

EQUIVALENT ICE MELTING CAPACITY

$$\frac{13,750.36}{144} = 95.48\#$$

EQUIVALENT POUNDS OF ICE PER 24 HOURS

$$\frac{24.00}{2.25} \times 95.48 = 1,017.82$$

TONNAGE OF MACHINE

$$\frac{1017.82 \times 144}{288000} = .509$$

TEST NO. 2

B.T.U. = 452-442 (64-42) x .766
168.52

464-452 (64-28) x .766
330.91

474-464 (64-20) x .766
491.04

488-474 (64-13) x .766
546.92

500-488 (64-7) x .766
523.94

512-500 (64-5) x .766
542.33

526-512 (64-2) x .766
664.89

537-526 (64-2) x .766
522.41

547-537 (64-1) x .766
482.58

Note: From 9.20 to 9.55 the expansion valve was closed account brine being frozen in coils.

564-551 (64.5-11) x .766
532.75

574-564 (64.5-15) x .766
379.17

585-574 (64.5-24) x .766
343.45

599-585 (64.5-28) x .766
391.43

615-599 (64-32) x .766
392.19

631-615 (64.5-27) x .766
459.60

645-631 (64.5-20) x .766
477.22

658-645 (65-15) x .766
497.90

670-658 (65-14) x .766
468.79

681-670 (65-12) x .766
446.58

697-681 (65-14) x .766
625.06

711-697 (65-14) x .766
546.92

724-711 (65-16) x .766
563.01

739-724 (65.5-16) x .766
569.14

753-739 (65.5-16) x .766
530.84

769-753 (65.5-16) x .766
606.67

781-769 (65.5-16) x .766
455.00

796-781 (65.5-18) x .766
545.78

811-796 (65.5-17) x .766
514.05

821-811 (65.5-17) x .766
371.51

836-821 (65.5-18) x .766
545.78

849-836 (65.5-18) x .766
473.01

863-849 (65.5-18) x.766
509.39

876-863 (65.5-19) x .766
463.05

890-876 (65.5-19) x .766
498.67

905-890 (65.5-19) x .766
534.29

915-905 (65.5-19) x .766
356.19

929-915 (66.5-18.5) x .766
514.75

942-929 (65.5-18) x .766
473.01

956-942 (66-18) x .766
514.75

968-956 (66-18) x .766
441.22

981-968 (66.18) x .766
477.98

994-981 (66-18) x .766
477.98

1008-994 (66.5-18.5) x .766
514.75

1020-1008 (66.5-18.5) x .766
441.22

1035-1020 (66.5-18.5) x .766
551.52

1045-1035 (66.0-18.5) x .766
363.85

1059-1045 (66.0-20) x .766
493.30

1074-1059 (66.0-21) x .766
517.05

1087-1074 (66.0-21) x .766
448.11

1100-1087 (66.0-21.5) x .766
453.09

1113-1100 (66.0-22) x .766
438.15

1127-1113 (66.0-20.5) x .766
487.94

1141-1127 (66.0-18) x .766
514.75

1154-1141 (66.0-17) x .766
487.94

1167-1154 (66.0-17) x .766
487.94

1178-1167 (66.0-23) x .766
362.32

1191-1178 (66.0-37.5) x .766
283.80

TOTAL B.T.U.

28,116.40

EQUIVALENT ICE MELTING CAPACITY

$$\frac{28,116.40}{144} = 195.25$$

EQUIVALENT POUNDS OF ICE PER 24 HOURS

$$\frac{24.00 \times 195.25}{5.25} = 892.29$$

TONNAGE OF MACHINE

$$\frac{892.29 \times 144}{288000} = .446$$

TEST NO. 3

B.T.U. = 368-355 (67-53) x .766
139.41

395-368 (65-40) x .766
517.05

420-395 (65-34.5) x .766
584.08

450-420 (65.5-30) x .766
815.79

475-450 (65.5-25.5) x .766
766.00

495-475 (65.5-22) x .766
666.42

521-495 (64-19)m x .766
907.92

546-521 (63-16.5) x .766
890.86

571-546 (63.5-14.5) x .766
950.60

595-571 (63.5-13) x .766
1315.22

620-595 (63.5-12) x .766
986.12

646-620 (63.5-12) x .766
826.51

675-646 (64-12) x .766
1155.13

694-675 (64-12) x .766
756.81

721-694 (64.12.5) x .766
1075.51

744-721 (64-13) x .766
898.52

770-744 (64-13.5) x .766
1005.76

791-770 (64-13.5) x .766
812.73

814-791 (64-12) x .766
916.14

835-814 (64-10) x .766
868.64

860-835 (64-12) x .766
995.80

887-860 (64.12) x .766
1075.46

912-887 (64-12) x .766
995.80

937-912 (64-11) x .766
1014.95

962-937 (64-11) x .766
1014.95

987-962 (64-10) x .766
1034.10

1015-987 (64-12.5) x .766
1104.57

1039-1015 (64-12.5) x .766
946.78

1065-1039 (64-17) x .766
936.05

1095-1065 (64-29) x .766
804.30

1105-1095 (64-38) x .766
199.16

TOTAL B.T.U.

26,977.14

EQUIVALENT ICE MELTING CAPACITY

$$\frac{26,977.14}{144} = 187.34$$

EQUIVALENT POUNDS OF ICE PER 24 HOURS

$$\frac{24.00}{2.53} \times 187.34 = 1875.98$$

TONNAGE OF MACHINE

$$\frac{1875.98 \times 144}{288000} = .938$$

TEST NO. 4

B.T.U. = 398-382 (62-42) x .766
245.12

415-398 (61.5-26) x .766
592.88

431-415 (61.5-18) x .766
533.14

501-431 (61.5-28) x .766
1796.27

566-501 (61.5-28) x .766
1668.35

599-566 (61.5-21) x .766
1044.14

630-599 (61.5-12) x .766
1175.81

671-630 (61.5-8) x .766
1680.60

719-671 (61-21) x .766
1470.72

760-719 (59.5-21) x .766
1209.51

804-760 (60-20) x .766
1348.16

835-804 (60-16) x .766
1044.82

860-835 (60-12) x .766
919.20

891-860 (60-9) x .766
1211.05

910-891 (60-9) x .766
742.25

934-910 (60.5-8) x .766
965.16

960-934 (60.5-7) x .766
1065.51

985-960 (61-7) x .766
1034.10

1010-985 (61-7) x .766
1034.10

1035-1010 (61-12) x .766
938.35

1060-1035 (61-27) x .766
651.10

1086-1060 (61-36) x .766
497.90

1114-1086 (61-42) x .766
407.51

1140-1114 (61-49) x .766
238.99

1158-1140 (61-53) x .766
110.30

TOTAL B.T.U.

23634.04

EQUIVALENT ICE MELTING CAPACITY

$$\frac{23634.04}{144} = 164.12\#$$

EQUIVALENT POUNDS OF ICE PER 24 HOURS

$$\frac{24.00}{2.05} \times 164.12 = 1,921.84$$

TONNAGE OF MACHINE

$$\frac{1921.84 \times 144}{288000} = .961$$

TEST NO. 5

B.T.U. = 369-366.5 (62-59.5) x .766
4.79

371-369 (61.5-58) x .766
5.36

373-371 (61-54.5) x .766
11.49

374.5-373 (61-53) x .766
9.19

375-374.5 (61-53.5) x .766
2.72

375.5-375 (60.5-47.5) x .766
4.98

376-375 (60.5-45) x .766
11.87

376.5-376 (60.5-45) x .766
5.94

377.5-376.5 (60.5-45) x .766
11.87

Note: Brine was turned off from 11.30 to 12.00 O'Clock Noon.

380.5-377.5 (61-29) x .766
73.54

386-380.5 (61.5-27) x .766
145.35

392-386 (62-36) x .766
119.50

394.5-392 (62.5-35.5) x .766
51.71

398-394.5 (62.5-39) x .766
63.00

401-398 (61-39) x .766
50.56

403.5-401 (61.5-39) x .766
43.09

406-403.5 (62-30.5) x .766
60.33

409-406 (61.5-28) x .766
76.98

411-409 (62-30) x .766
48.02

414-411 (63-36) x .766
61.05

416-414 (62.5-40) x .766
34.47

419-416 (64-36) x .766
64.34

422-419 (64-38) x .766
59.75

423-422 (64-41) x .766
17.62

425-423 (64-30) x .766
52.09

428-425 (65-19) x .766
105.71

431.5-428 (64-27.5) x .766
97.86

435-431.5 (64.5-38) x .766
71.05

438.5-435 (64.5-40) x .766
65.68

441-438.5 (65-38) x .766
51.71

442.5-441 (65-35.5) x .766
33.90

444-442.5 (65-36) x .766
33.32

445.5-444 (65-38) x .766
31.02

450-445.5 (64.5-32) x .766
112.03

454-450 (64.5-38) x .766
81.19

456-454 (64.5-40) x .766
37.53

458-456 (66-27) x .766
59.75

460.5-458 (66-29) x .766
70.86

463.5-460.5 (65.5-38.5) x .766
62.05

465.5-463.5 (66-45) x .766
32.17

468.5-465.5 (65-45) x .766
45.96

472-468.5 (66-34) x .766
85.79

474.5-472 (66-39) x .766
51.71

477-474.5 (66-31) x .766
67.03

482.5-477 (65.5-39) x.766
111.64

487.5-482.5 (66.5-46) x .766
74.69

492-487.5 (66-37) x .766
99.96

496.5-492 (66-42) x .766
75.07

501-496.5 (65-25) x .766
137.88

506-501 (63.5-29) x .766
130.22

512-506 (63-45) x .766
82.73

518-512 (63-21) x .766
193.03

527-518 (62.5-19) x .766
299.89

551-527 (62.5-46) x .766
303.34

594-551 (62-17) x .766
148.22

704-594 (62.5-35) x .766
231.72

738-704 (63-15) x .766
225.01

787.5-738 (63.5-35) x .766
1056.12

832-787.5 (62.5-39) x .766
801.04

881.5-832 (63.5-40) x .766
1056.12

907-881.5 (63.5-27) x .766
891.05

932-907 (63.5-23.7) x .766
762.17

954-932 (63-24) x .766
657.23

980-954 (63-24) x .766
783.92

997-980 (63-31) x .766
416.70

1014-997 (63-32) x .766
303.68

1029.5-1014 (63-35) x .766
332.44

1045-1029.5 (63.30) x ,766
391.81

1060-1045 (62.5-29.5) x .766
379.70

1074-1060 (62.5-32) x .766
321.72

1089-1074 (62.5-37) x .766
293.00

1101-1089 (62-32) x .766
275.76

1117-1101 (62-32) x .766
367.68

1129.5-1117 (62-31) x .766
296.83

1144-1129.5 (62-35) x .766
272.89

1159-1444 (62-46) x .766
183.84

1176-1159 (62-37) x .766
325.55

1191-1176 (62-40) x .766
252.78

1207.5-1191 (62-42) x .766
252.78

1221-1207.5 (62-25) x .766
382.62

1248-1221 (61.5-33) x .766
589.44

1276-1248 (61.5-33) x .766
611.27

1299.5-1276 (61-35) x .766
468.03

1316-1299.5 (61-25) x .766
455.00

1337-1316 (61-32) x .766
466.49

1357-1337 (61.5-29) x .766
497.90

1373-1357 (61.5-29) x .766
398.32

1389-1373 (61.5-29) x .766
398.32

1404-1389 (60.5-29) x .766
361.94

1420-1404 (59.5-31) x .766
349.30

1436-1420 (59-32) x .766
317.12

1451-1436 (59-34) x .766
287.25

1465-1461 (60-35) x .766
270.10

1480-1465 (60-36) x .766
275.76

1495-1480 (60-38) x .766
252.78

1509-1495 (60-41) x .766
203.76

1522-1509 (60.5-43) x .766
174.27

1535-1522 (60.5-45) x .766
154.35

1551-1535 (61-48) x .766
159.33

1564-1551 (61-50) x .766
109.54

1577-1564 (61-28) x .766
328.61

1590-1577 (61.5-23) x . 766
383.38

1599-1590 (61.5-48) x .766
93.07

1603-1599 (61.5-53) x .766
26.04

TOTAL B.T.U.
23,059.96

EQUIVALENT ICE MELTING CAPACITY

$$\frac{23,059.96}{144} = 160.13\#$$

EQUIVALENT POUNDS OF ICE PER 24 HOURS

$$\frac{24.00}{26.25} \times 160.13 = 146.2$$

TONNAGE OF MACHINE

$$\frac{146.2 \times 144}{288000} = .0731$$

ECONOMY CALCULATIONS

Total Water used:

2394 pounds.

1 Gallon of Water weighs 8.33 pounds.

$\frac{2394}{8.33} = $ 287.39 gallons water used.

Water costs 7¢ per 1000 gallons.

$\frac{0.07}{1000} = $ 0.00007¢ cost of one gallon.

Cost of water used.

287.39 x 0.00007 = 0.02012¢.

Total Gas burned.

364 cubic feet.

Cost of Gas.

0.80 per 1000 cubic feet.

Cost of Gas per cubic foot.

$\frac{0.80}{1000} = $ 0.0008.

Cost of Gas consumed.

364 x 0.0008 = 0.2912.

Total cost of operation.

$0.3113

Cost of refrigeration equivalent to one hundred pounds of ice.

$\frac{0.3113}{1.9525} = $ 0.1599

Cost of ice.

0.40 per one hundred pounds.

Difference in price.

0.40 - 0.1599 = 0.2401.

Percentage of saving by using machine over using ice.

$$\frac{0.2401}{0.40} \times 100 = 60.025\%.$$

PART 7.

DATA AND CURVES

LOG TEST NO. 1

6.15 a.m	Gas lighted under generator.
6.45 a.m	Valve opened to condenser at ammonia pressure of 50#.
6.55 a.m	Water turned into cooling coils in condenser at ammonia pressure of 100#.
8.20 a.m	Gas turned off. Water turned into cooling coils in absorber and generator. Water turned off from cooling coils in condenser.
8.45 a.m	Water turned off from cooling coils of absorber and generator, vacuum gauge reading 25 inches of mercury.

365 cu. ft. Gas consumed.

MECHANICAL ENGINEERING LABORATORY

ARMOUR INSTITUTE OF TECHNOLOGY

Test of Autovacuum Refrigerating Machine No. 1.   *Date* May 13th, 1915.

Thesis Test No. 1.   Room Temperature 72° F.

Observer Sherwood - Wong - Agee

Time	Wt. of Brine	Temp. of Brine Inlet	Temp. of Brine Outlet	Cooling Water Inlet	Cooling Water Outlet	Vac. Gauge in.Hg.
9.30	332.0	67.0	69.0	56.0	59.0	25.0
9.35	347.0	65.0	55.0	56.0	59.0	25.0
9.40	357.5	64.0	44.0	54.0	57.0	25.0
9.45	360.5	64.0	36.0	53.0	58.5	23.0
9.50	362.5	64.0	32.5	53.0	61.0	23.0
9.55	360.0	64.0	28.0	54.0	62.0	20.0
10.00	371.5	64.0	22.0	54.0	61.0	18.0
10.05	386.0	64.0	17.0	54.0	63.0	17.0
10.10	400.0	64.0	15.0	53.5	64.0	13.0
10.15	412.5	64.0	12.0	53.5	65.0	13.0
10.20	425.5	64.0	12.0	53.5	65.0	12.0
10.25	438.5	64.0	10.0	53.5	65.0	10.0
10.30	451.5	64.0	7.5	53.5	65.0	8.0
10.35	464.5	64.0	7.0	53.5	65.0	8.0

Time	Wt. of Brine	Temp. of Brine Inlet	Temp. of Brine Outlet	Cooling Water Inlet	Cooling Water Outlet	Vac. Gauge in.Hg.
10.40	476.5	64.5	6.5	53.5	65.0	7.0
10.45	495.0	64.5	6.0	54.0	65.5	5.0
10.50	513.5	64.5	6.0	54.0	65.5	3.0
10.55	534.0	64.5	6.0	54.0	65.5	1.0
11.00	551.0	64.5	6.5	54.0	65.5	0
11.05	568.5	64.5	7.5	54.0	65.5	lbs. 2.0
11.10	583.0	64.5	8.0	54.0	65.0	2.0
11.15	606.0	64.5	8.5	54.0	65.0	3.0
11.20	612.0	64.5	9.0	54.0	65.0	3.0
11.25	623.5	64.5	8.0	54.0	65.0	4.0
11.30	637.0	64.5	8.0	54.0	65.0	5.0
11.35	651.0	65.0	8.0	54.0	63.0	6.0
11.40	664.5	65.0	9.0	54.0	61.0	7.0
11.45	679.5	65.0	12.0	54.0	60.5	7.5

LOG TEST NO. 2

4.32 a.m Gas lighted under generator.

5.05 a.m Valve opened to condenser at ammonia pressure of 50#.

5.15 a.m Water turned into cooling coils in condenser at ammonia pressure of 95#.

6.45 a.m Gas turned off.
Water turned into cooling coils in absorber and generator.
Water turned off from cooling coils in condenser.

1287# - Weight of water necessary to condense ammonia gas.

1425# - Weight of water necessary to obtain vacuum of 29 inches of mercury.

361 cu. ft. Gas consumed.

Form 11

MECHANICAL ENGINEERING LABORATORY

ARMOUR INSTITUTE OF TECHNOLOGY

Test of Autovacuum Refrigerating Machine No. 1. *Date* May 14th, 1915.

Thesis Test No. 2. Room Temperature 73.5° F.

Observer Sherwood - Wong - Agee

Time	Wt. of Brine	Temp. of Brine Inlet	Outlet	Cooling Water Inlet	Outlet	Vac. Gauge in.Hg.	Time	Wt. of Brine	Temp. of Brine Inlet	Outlet	Cooling Water Inlet	Outlet	Vac. Gauge in.Hg.
8.35	442.0	64.0	64.0	53.0	56.0	29.0	9.45		65.5	7.0	53.0	56.5	21.0
8.40	452.0	64.0	42.0	53.0	57.0	28.0	9.50		61.5	51.0	53.0	55.0	22.0
8.45	464.0	64.0	28.0	53.0	58.0	26.0	9.55	564.0	64.5	11.0	53.0	55.0	22.0
8.50	474.0	64.0	20.0	53.0	59.0	26.0	10.00	574.0	64.5	15.0	53.0	55.0	22.0
8.55	488.0	64.0	13.0	53.0	59.5	25.0	10.05	585.0	64.5	24.0	53.0	54.5	23.0
9.00	500.0	64.0	7.0	53.0	59.0	25.0	10.10	599.0	64.5	28.0	53.0	54.5	23.0
9.05	512.0	64.0	5.0	53.0	59.0	25.0	10.15	615.0	64.0	32.0	53.0	55.0	23.0
9.10	526.0	64.0	2.0	53.0	59.0	25.0	10.20	631.0	64.5	27.0	53.0	55.0	22.0
9.15	537.0	64.0	2.0	53.0	59.0	24.0	10.25	645.0	64.5	20.0	53.0	55.0	21.0
9.20	547.0	64.0	1.0	53.0	59.0	24.0	10.30	658.0	65.0	15.0	53.0	55.5	21.0
*9.25		64.5	0.0	53.0	57.0	24.0	10.35	670.0	65.0	14.0	53.0	56.0	19.0
9.30	550.0	64.0	1.5	53.0	56.0	23.0	10.40	681.0	65.0	12.0	53.0	56.5	18.0
9.35	551.0	65.0	4.0	53.0	56.0	22.0	10.45	697.0	65.0	14.0	53.0	56.5	18.0
9.40		65.0	5.0	53.0	56.0	21.0	10.50	711.0	65.0	14.0	53.0	57.0	16.0

*Brine frozen from 9.25 to 9.50

Form 11

MECHANICAL ENGINEERING LABORATORY

ARMOUR INSTITUTE OF TECHNOLOGY

Test of Autovacuum Refrigerating Machine No. 1.

Date May 14th, 1915.

Thesis Test No. 2.

Room Temperature 73.5° F.

Observer Sherwood - Wong - Agee

Time	Wt. of Brine	Temp. of Brine Inlet	Temp. of Brine Outlet	Cooling Water Inlet	Cooling Water Outlet	Vac. Gauge in.Hg.
10.55	724.0	65.0	16.0	53.0	57.0	15.0
11.00	739.0	65.5	16.0	53.0	57.0	15.0
11.05	753.0	65.5	16.0	53.0	57.0	15.0
11.10	769.0	65.5	16.0	53.0	57.0	15.0
11.15	781.0	65.5	16.0	53.0	57.0	13.0
11.20	796.0	65.5	18.0	53.0	57.0	12.0
11.25	811.0	65.5	17.0	53.0	57.0	11.0
11.30	821.0	65.5	17.0	53.0	57.0	11.0
11.35	836.0	65.5	18.0	53.0	57.5	11.0
11.40	849.0	65.5	18.0	53.0	57.0	11.0
11.45	863.0	65.5	18.0	53.0	57.0	11.0
11.50	876.0	65.5	19.0	53.0	57.0	11.0
11.55	890.0	65.5	19.0	53.0	57.0	10.0
12.00	905.0	65.5	19.0	53.0	57.0	10.0
12.05	915.0	65.5	19.0	53.0	57.0	10.0
12.10	929.0	66.5	18.5	53.0	57.0	10.0
12.15	942.0	65.5	18.0	53.0	57.0	10.0
12.20	956.0	66.0	18.0	53.0	57.5	10.0
12.25	968.0	66.0	18.0	53.0	57.0	10.0
12.30	981.0	66.0	18.0	53.0	57.0	10.0
12.35	994.0	66.0	18.0	53.0	57.0	9.0
12.40	1008.	66.5	18.5	53.0	57.0	9.0
12.45	1020.	66.5	18.5	53.0	57.0	9.0
12.50	1035.	66.5	18.5	53.0	57.0	8.0
12.55	1045.	66.0	18.5	53.0	57.0	8.0
1.00	1059.	66.0	20.0	53.0	57.0	8.0
1.05	1074.	66.0	21.0	53.0	57.0	7.0
1.10	1087.	66.0	21.0	53.0	57.0	7.0

Form 11

MECHANICAL ENGINEERING LABORATORY

ARMOUR INSTITUTE OF TECHNOLOGY

Test of Autovacuum Refrigerating Machine No. 1. *Date* May 14th, 1915.

Thesis Test No. 2. Room Temperature 73.5° F.

Observer Sherwood - Wong - Agee

Time	Wt. of Brine	Temp. of Brine Inlet	Temp. of Brine Outlet	Cooling Water Inlet	Cooling Water Outlet	Vac. Gauge in.Hg.	Time	Wt. of Brine	Temp. of Brine Inlet	Temp. of Brine Outlet	Cooling Water Inlet	Cooling Water Outlet	Vac. Gauge in.Hg.
1.15	1100.	66.0	21.5	53.0	57.0	7.0	1.35	1154.	66.0	17.0	53.0	57.0m	3.0
1.20	1113.	66.0	22.0	53.0	57.0	6.0	1.40	1167.	66.0	17.0	53.0	57.0	0.
1.25	1127	66.0	20.5	53.0	57.0	5.0	1.45	1178.	66.0	23.0	53.0	57.0	0.
1.30	1141.	66.0	18.0	53.0	57.0	5.0	1.50	1191.	66.0	37.5	53.0	56.5	0.

LOG TEST NO. 3.

1.55 p.m	Gas lighted under generator.
2.10 p.m	Valve opened to condenser at ammonia pressure of 50#.
2.25 p.m	Water turned into cooling coils in condenser at ammonia pressure of 110#.
3.35 p.m	Gas turned off. Water turned into cooling coil in absorber and generator. Water turned off from cooling coil in condenser.
4.00 p.m	Water turned off from cooling coil in absorber and generator, vacuum gauge reading 25 inches of mercury.

380 cu. ft. Gas consumed.

The ammonia was boiled off at a maximum pressure of 160#.

Form 11

MECHANICAL ENGINEERING LABORATORY

ARMOUR INSTITUTE OF TECHNOLOGY

Test of Autovacuum Refrigerating Machine No. 1. Date May 14th, 1915.

Thesis Test No. 3. Room Temperature 71°

Observer Sherwood - Wong - Agee

Time	Wt. of Brine	Temp. of Brine		Cooling Water		Vac. Gauge in.Hg.
		Inlet	Outlet	Inlet	Outlet	
4.25	355.0	68.0	64.0	55.0	57.5	26.0
4.30	368.0	66.0	53.0	54.0	61.0	27.0
4.35	395.0	65.0	40.0	54.0	60.0	27.0
4.40	420.0	65.0	34.5	53.5	60.0	25.0
4.45	450.0	65.5	30.0	53.5	60.0	22.5
4.50	475.0	65.5	25.5	53.5	60.5	22.5
4.55	495.0	65.5	22.0	53.5	60.5	22.5
5.00	521.0	64.0	19.0	53.5	60.5	21.0
5.05	546.0	63.0	16.5	53.5	61.0	20.0
5.10	571.0	63.5	14.5	53.5	61.0	19.0
5.15	595.0	63.5	13.0	53.5	61.0	18.0
5.20	620.0	63.5	12.0	53.5	60.5	18.0
5.25	646.0	63.5	12.0	53.5	60.5	18.0
5.30	675.0	64.0	12.0	53.5	60.5	17.0
5.35	694.0	64.0	12.0	53.5	60.5	17.0
5.40	721.0	64.0	12.5	53.5	60.0	15.0

Time	Wt. of Brine	Temp. of Brine		Cooling Water		Vac. Gauge in.Hg.
		Inlet	Outlet	Inlet	Outlet.	
5.45	744.0	64.0	13.0	53.5	60.0	14.0
5.50	770.0	64.0	13.5	53.5	60.0	13.0
5.55	791.0	64.0	13.5	53.5	60.0	12.0
6.00	814.0	64.0	12.0	53.5	60.0	12.0
6.05	835.0	64.0	10.0	53.5	60.0	11.0
6.10	860.0	64.0	12.0	53.5	60.0	10.0
6.15	887.0	64.0	12.0	53.5	60.0	9.0
6.20	912.0	64.0	12.0	53.5	60.0	8.0
6.25	937.0	64.0	11.0	53.5	60.0	7.0
6.30	962.0	64.0	11.0	53.5	60.5	7.0
6.35	987.0	64.0	10.0	53.5	60.5	6.0
6.40	1015.	64.0	12.5	53.5	60.5	5.0
6.45	1039.	64.0	12.5	53.5	60.0	4.0
6.50	1065.	64.0	17.0	53.5	58.0	3.0
6.55	1095.	64.0	29.0	53.5	56.5	0.
6.57	1105.	64.0	38.0	53.5	56.0	0.

LOG TEST NO. 4

4.49 a.m Gas lighted under generator.

5.10 a.m Valve opened to condenser at ammonia pressure of 50#.

5.25 a.m Water turned into cooling coil of condenser at ammonia pressure of 100#.

7.40 a.m Gas turned off.
Water turned into cooling coils in absorber and generator.
Water turned off from cooling coils in condenser.

8.15 a.m Water turned off from cooling coils of absorber and generator, vacuum gauge reading 28 inches of mercury.

1213 lbs. - Weight of water necessary to condense ammonia gas.

1424 lbs. - Weight of water necessary to obtain vacuum of 28 inches of mercury.

359 cu. ft. Gas consumed.

Ammonia was boiled off at a maximum pressure of 250 lbs.

MECHANICAL ENGINEERING LABORATORY

ARMOUR INSTITUTE OF TECHNOLOGY

Test of Autovacuum Refrigerating Machine No. 1.

Date May 15th, 1915.

Thesis Test No. 4.

Room Temperature 69°

Observer Sherwood - Wong - Agee

Time	Wt. of Brine	Temp. of Brine Inlet	Temp. of Brine Outlet	Cooling Water Inlet	Cooling Water Outlet	Vac. Gauge in. Hg.
8.20	382.0	62.5	61.0	54.0	58.5	28.0
8,25	398.0	61.5	42.0	53.5	61.0	25.0
8.30	415.0	61.5	26.0	53.5	61.5	24.0
8.35	431.0	61.5	18.0	53.5	61.5	23.0
8.40	501.0	61.5	28.0	53.5	63.0	22.0
8.45	566.0	61.5	28.0	53.5	63.0	21.0
8.50	599.0	61.5	21.0	53.5	63.0	20.0
8.55	630.0	61.5	12.0	53.5	63.0	20.0
9.00	671.0	61.5	8.0	53.5	63.0	19.0
9.05	719.0	61.0	21.0	53.5	68.0	15.0
9.10	760.0	59.5	21.0			9.0
9.15	804.0	60.0	20.0	55.0	69.0	9.0
9.20	835.0	60.0	16.0	53.5	66.5	9.0
9.25	860.0	60.0	12.0	53.5	66.0	9.0
9.30	891.0	60.0	9.0	53.5	65.0	8.0
9.35	910.0	60.0	9.0	53.5	65.0	5.0
9.40	934.0	60.5	8.0	53.5	65.0	5.0
9.45	960.0	60.5	7.0	53.5	64.0	4.0
9.50	985.0	61.0	7.0	53.5	64.0	3.0
9.55	1010.	61.0	7.0	53.5	59.0	0 lbs
10.00	1035.	61.0	12.0	53.5	57.5	4
10.05	1060.	61.0	27.0	53.5	56.5	4
10.10	1086.	61.0	36.0	53.5	56.0	5
10.15	1114.	61.0	42.0	53.5	56.0	5
10.20	1140.	61.0	49.0	53.5	56.0	5
10.23	1158.	61.0	53.0	53.5	56.0	7

LOG TEST NO. 5.

6.08 a.m	Gas lighted under generator.
6.29 a.m	Valve opened to condenser at ammonia pressure of 50#.
6.39 a.m	Water turned into cooling coil of condenser, at ammonia pressure of 100#.
8.32 a.m	Gas turned off. Water turned into cooling coil of absorber and generator. Water turned off from colling coil in condenser.

365 cu. ft. Gas consumed.

Ammonia was boiled off at pressure of 125 to 150 pounds.

Form 11

MECHANICAL ENGINEERING LABORATORY

ARMOUR INSTITUTE OF TECHNOLOGY

Test of Autovacuum Refrigerating Machine No. 1.

Date May 17th, 1915.

Thesis Test No. 5.

Room Temperature 62.5°

Observer Sherwood - Wong - Agee

Time	Wt. of Brine	Temp. of Brine Inlet	Temp. of Brine Outlet	Cooling Water Inlet	Cooling Water Outlet	Vac. Gauge in.Hg.
9.15	366.5	63.0	61.0	53.5	58.0	29.0
9.30	369.0	62.0	59.5	53.5	56.0	29.0
9.45	371.0	61.5	58.0	53.5	55.0	29.0
10.00	373.0	61.0	54.5	53.5	55.0	29.0
10.15	374.5	61.0	53.0	53.5	54.5	28.0
10.30	375.0	61.0	53.5	53.5	54.0	28.0
10.45	375.5	60.5	47.5	53.5	54.0	28.0
11.00	376.0	60.5	45.0	53.5	54.0	27.0
11.15	376.5	60.5	45.0	53.5	54.0	27.0
11.30	377.5	60.5	45.0	53.5	54.0	27.0
11.45	377.5	60.5	46.5	53.5	54.0	27.0
12.00	377.5	60.5	43.0	53.5	54.0	27.0
12.15	380.5	61.0	29.0	53.5	54.0	27.0
12.30	386.0	61.5	27.0	53.5	54.0	27.0
12.45	392.0	62.0	36.0	53.5	54.0	27.0
1.00	394.5	62.5	35.5	53.5	54.0	27.0
1.15	398.0	62.5	39.0	53.0	53.5	27.0
1.30	401.0	61.0	39.0	53.0	53.5	27.0
1.45	403.5	61.5	39.0	53.0	53.5	27.0
2.00	406.0	62.0	30.5	53.0	53.5	27.0
2.15	409.0	61.5	28.0	53.0	53.5	27.0
2.30	411.0	62.0	30.0	53.0	53.5	27.0
2.45	414.0	63.0	36.0	53.0	53.5	27.0
3.00	416.0	62.5	40.0	53.0	53.5	27.0
3.15	419.0	64.0	36.0	53.0	53.5	27.0
3.30	422.0	64.0	38.0	53.0	53.5	27.0
3.45	423.0	64.0	41.0	53.0	53.5	27.0
4.00	425.0	64.0	30.0	53.0	53.5	27.0

Form 11

MECHANICAL ENGINEERING LABORATORY

ARMOUR INSTITUTE OF TECHNOLOGY

Test of Autovacuum Refrigerating Machine No..1.

Date May 17th, 1915.

Thesis Test No. 5.

Room Temperature 62.5^{0}

Observer Sherwood - Wong - Agee

Time	Wt. of Brine	Temp. of Brine Inlet	Temp. of Brine Outlet	Cooling Water Inlet	Cooling Water Outlet	Vac. Gauge in.Hg.	Time	Wt. of Brine	Temp. of Brine Inlet	Temp. of Brine Outlet	Cooling Water Inlet	Cooling Water Outlet	Vac. Gauge in.Hg.
4.15	428.0	65.0	19.0	53.0	53.5	27.0	7.45	465.5	66.0	45.0	53.0	54.0	27.0
4.30	431.5	64.0	27.5	53.0	53.5	27.0	8.00	468.5	65.0	45.0	53.5	54.0	27.0
4.45	435.0	64.5	38.0	53.0	53.5	27.0	8.15	472.0	66.0	34.0	53.5	54.0	26.0
5.00	438.5	64.5	40.0	53.0	53.5	27.0	8.30	474.5	66.0	39.0	53.5	54.0	26.0
5.15	441.0	65.0	38.0	53.0	54.0	27.0	8.45	477.0	66.0	31.0	53.5	54.0	26.0
5.30	442.5	65.0	35.5	53.0	53.5	27.0	9.00	482.5	65.5	39.0	53.5	54.0	26.0
5.45	444.0	65.0	36.0	53.0	53.5	27.0	9.15	487.5	65.5	46.0	53.5	54.0	26.0
6.00	445.5	65.0	38.0	53.0	53.5	27.0	9.30	492.0	66.0	37.0	53.5	54.0	26.0
6.15	450.0	64.5	32.0	53.0	53.5	27.0	9.45	496.5	66.0	42.0	53.5	54.0	26.0
6.30	454.0	64.5	38.0	53.0	53.5	27.0	10.00	501.0	65.0	25.0	53.5	54.0	25.0
6.45	456.0	64.5	40.0	53.0	53.5	27.0	10.15	506.0	63.5	29.0	53.5	54.0	25.0
7.00	458.0	66.0	27.0	53.5	54.0	27.0	10.30	512.0	63.0	45.0	53.5	54.0	25.0
7.15	460.5	66.0	29.0	53.5	54.0	27.0	10.45	518.0	63.0	21.0	53.5	54.0	25.0
7.30	463.5	65.5	38.5	53.0	53.5	27.0	11.00	527.0	62.5	19.0	53.5	54.0	25.0

Form 11

MECHANICAL ENGINEERING LABORATORY

ARMOUR INSTITUTE OF TECHNOLOGY

Test of Autovacuum Refrigerating Machine No. 1.

Date May 17th, 1915.

Thesis Test No. 5.

Room Temperature 62.5^0

Observer Sherwood - Wong - Agee

Time	Wt. of Brine	Temp. of Brine Inlet	Temp. of Brine Outlet	Cooling Water Inlet	Cooling Water Outlet	Vac. Gauge in.Hg.
11.15	551.0	62.5	46.0	53.5	54.0	25.0
11.30	594.0	62.0	17.0	53.5	56.5	24.0
11.45	704.0	62.5	35.0	53.5	55.5	20.0
12.00	738.0	63.0	15.0	53.5	57.0	19.0
12.15	787.5	63.5	35.0	53.5	55.0	19.0
12.30	832.0	62.5	39.0	53.0	55.0	19.0
12.45	881.5	63.5	40.0	53.0	55.0	19.0
1.00	907.0	63.5	27.0	53.0	55.0	18.0
1.15	932.0	63.5	23.5	53.0	55.0	17.0
1.30	954.0	63.0	24.0	53.0	55.0m	16.0
1.45	980.0	63.0	29.5	53.0	54.5	15.0
2.00	997.0	63.0	31.0	53.0	54.5	15.0
2.15	1014.	63.0	32.0	53.0	54.0	14.0
2.30	1029.5	63.0	35.0	53.0	54.0	14.0
2.45	1045.	63.0	30.0	53.0	54.0	15.0
3.00	1060.	62.5	29.5	53.0	54.0	16.0
3.15	1074.	62.5	32.0	53.0	54.0	16.0
3.30	1089.	62.5	37.0	53.0	54.0	15.0
3.45	1101.	62.0	32.0	63.0	54.0	15.0
4.00	1117.	62.0	30.0	53.0	54.0	15.0
4.15	1129.5	62.0	31.0	53.0	54.0	15.0
4.30	1144.	62.0	35.0	53.0	54.0	15.0
4.45	1159.	62.0	46.0	53.0	54.0	15.0
5.00	1176.	62.0	37.0	53.0	54.0	15.0
5.15	1191.	62.0	40.0	53.0	54.0	15.0
5.30	1207.5	62.0	42.0	53.0	54.0	15.0
5.45	1221.	62.0	25.0	53.0	54.0	15.0
6.00	1248.	61.5	33.0	53.0	54.0	14.0

Form 11

MECHANICAL ENGINEERING LABORATORY

ARMOUR INSTITUTE OF TECHNOLOGY

Test of Autovacuum Refrigerating Machine No. 1. *Date* May 17th, 1915.

Thesis Test No. 5. Room Temperature 62.5°

Observer Sherwood - Wong - Agee

Time	Wt. of Brine	Temp. of Brine Inlet	Temp. of Brine Outlet	Cooling Water Inlet	Cooling Water Outlet	Vac. Gauge in. Hg.
6.15	1276.	61.5	33.0	53.0	54.0	13.0
6.30	1299.5	61.0	35.0	53.0	54.0	13.0
6.45	1316.	61.0	25.0	53.0	54.0	13.0
7.00	1337.	61.0	32.0	53.0	54.5	13.0
7.15	1357.	61.5	29.0	53.0	54.5	12.0
7.30	1373.	61.5	29.0	53.0	54.5	12.0
7.45	1389.	61.5	29.0	53.5	54.5	11.0
8.00	1404.	60.5	29.0	53.5	54.5	11.0
8.15	1420.	59.5	31.0	53.5	54.5	10.0
8.30	1436.	59.0	32.0	53.5	54.5	9.0
8.45	1451.	59.0	34.0	53.5	54.5	9.0
9.00	1465	60.0	35.0	53.5	54.5	9.0

Time	Wt. of Brine	Temp. of Brine Inlet	Temp. of Brine Outlet	Cooling Water Inlet	Cooling Water Outlet	Vac. Gauge in. Hg.
9.15	1480	60.0	36.0	53.5	54.5	9.0
9.30	1495.	60.0	38.0	53.5	54.5	9.0
9.45	1509.	60.5	41.0	53.0	54.0	9.0
10.00	1522.	60.5	43.0	53.0	54.0	9.0
10.15	1535.	60.5	45.0	53.0	54.0	9.0
10.30	1551.	61.0	48.0	53.0	54.0	9.0
10.45	1564.	61.0	50.0	53.0	54.0	9.0
11.00	1577.	61.0	28.0	53.5	54.0	9.0
11.15	1590.	61.5	23.0	53.5	54.0	9.0
11.25	1599.	61.5	48.0	53.5	54.0	5.0
11.30	1603.	61.5	53.0	53.5	54.0	5.0

LOG OF ECONOMY TEST

2.19 p.m Gas lighted under generator.

2.35 p.m Valve cracked to condenser at ammonia pressure of fifty pounds.

2.50 p.m Water turned into cooling coils in condenser at ammonia pressure of one hundred and twenty five pounds.

5.05 p.m Gas turned off.
Water turned into cooling coils in absorber and generator.
Water turned off from cooling coils in condenser.

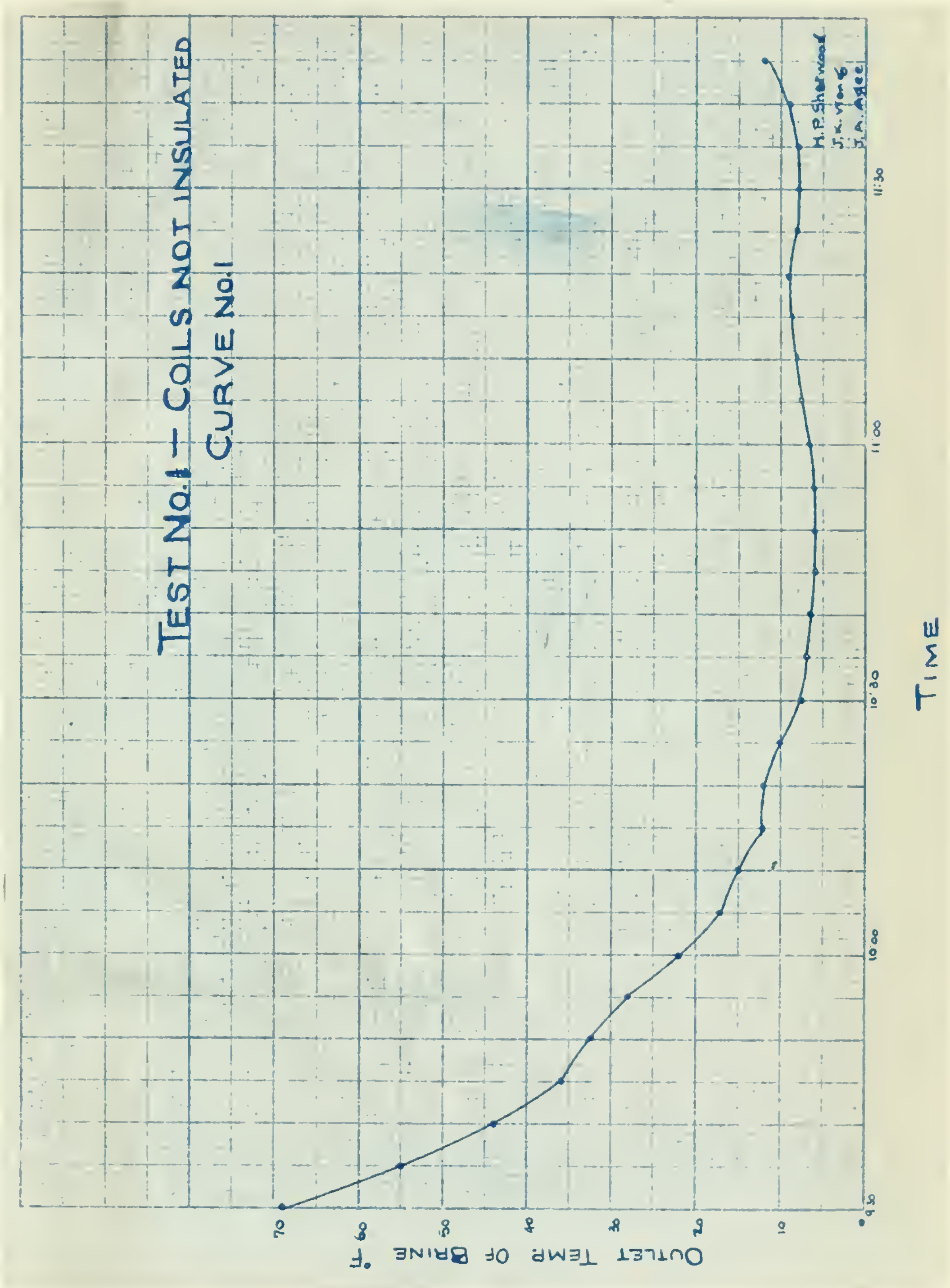
5.40 p.m Cooling water turned off in cooling coil of absorber and generator.

1265 lbs. - Weight of water necessary to condense ammonia gas.

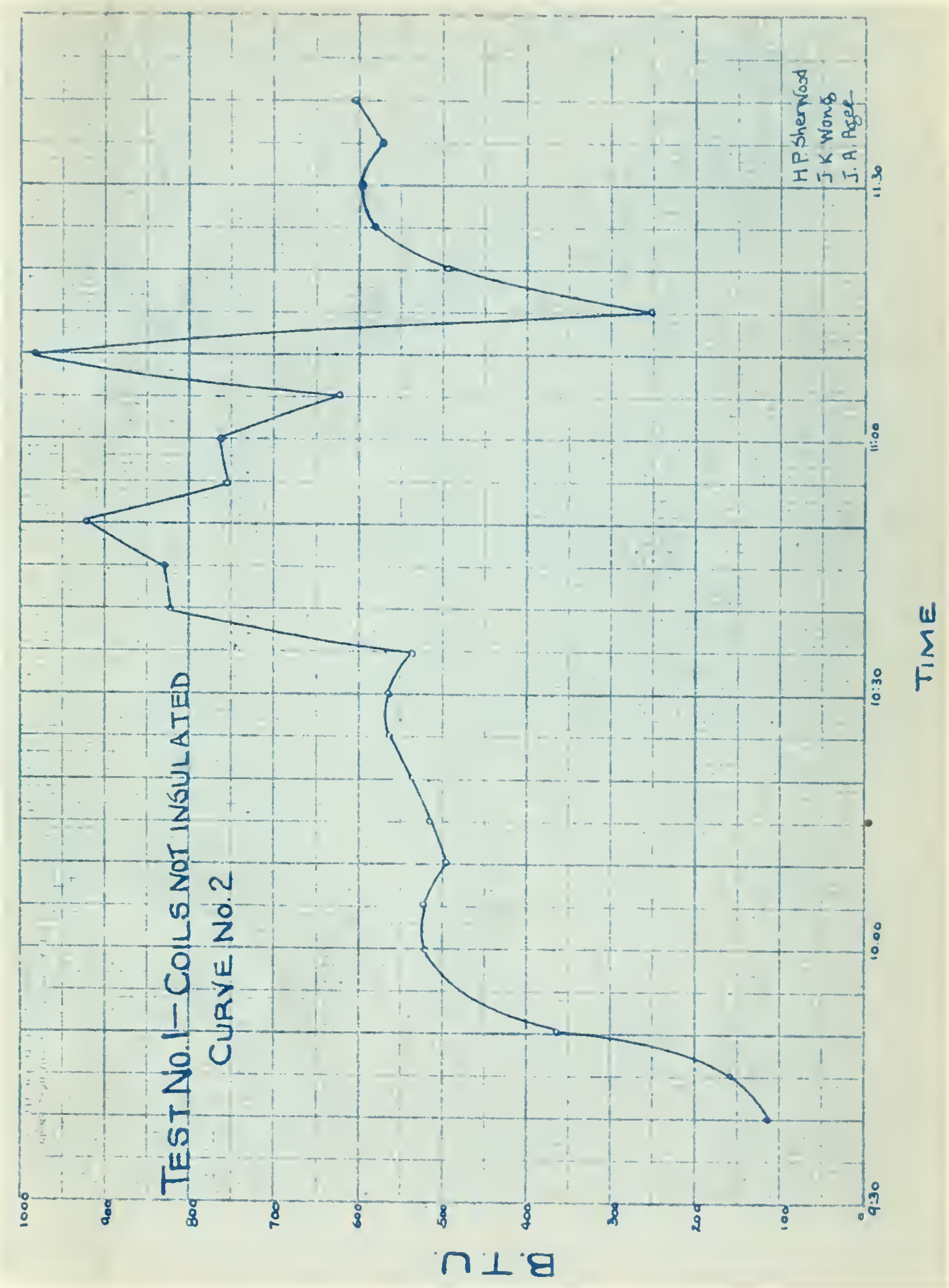
1129 lbs. - Weight of water necessary to obtain vacuum of 29 inches of mercury.

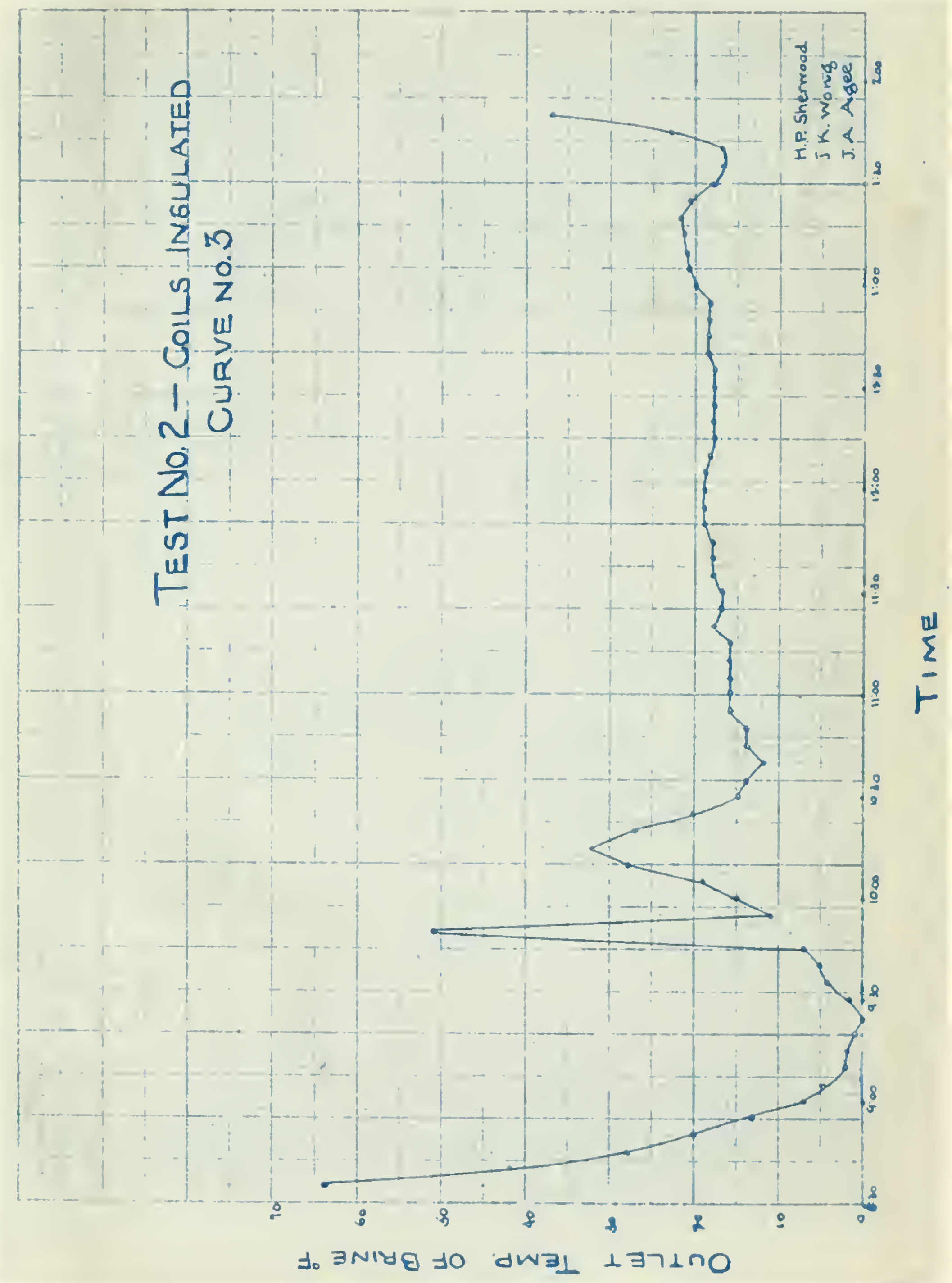
364. cu. ft. Gas consumed.

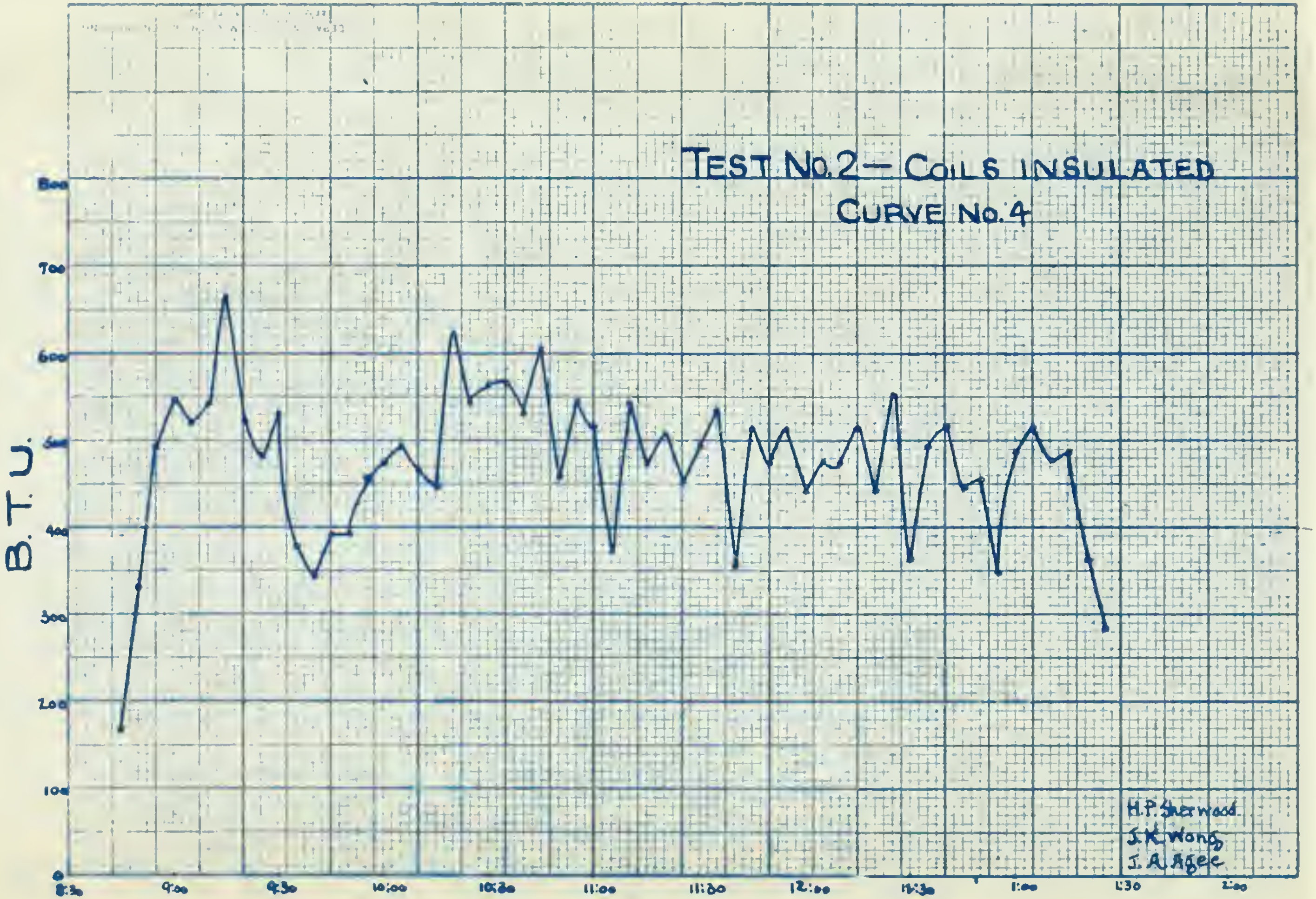
The ammonia pressure gauge registered from 125 to 150 pounds throughout the entire boiling off.

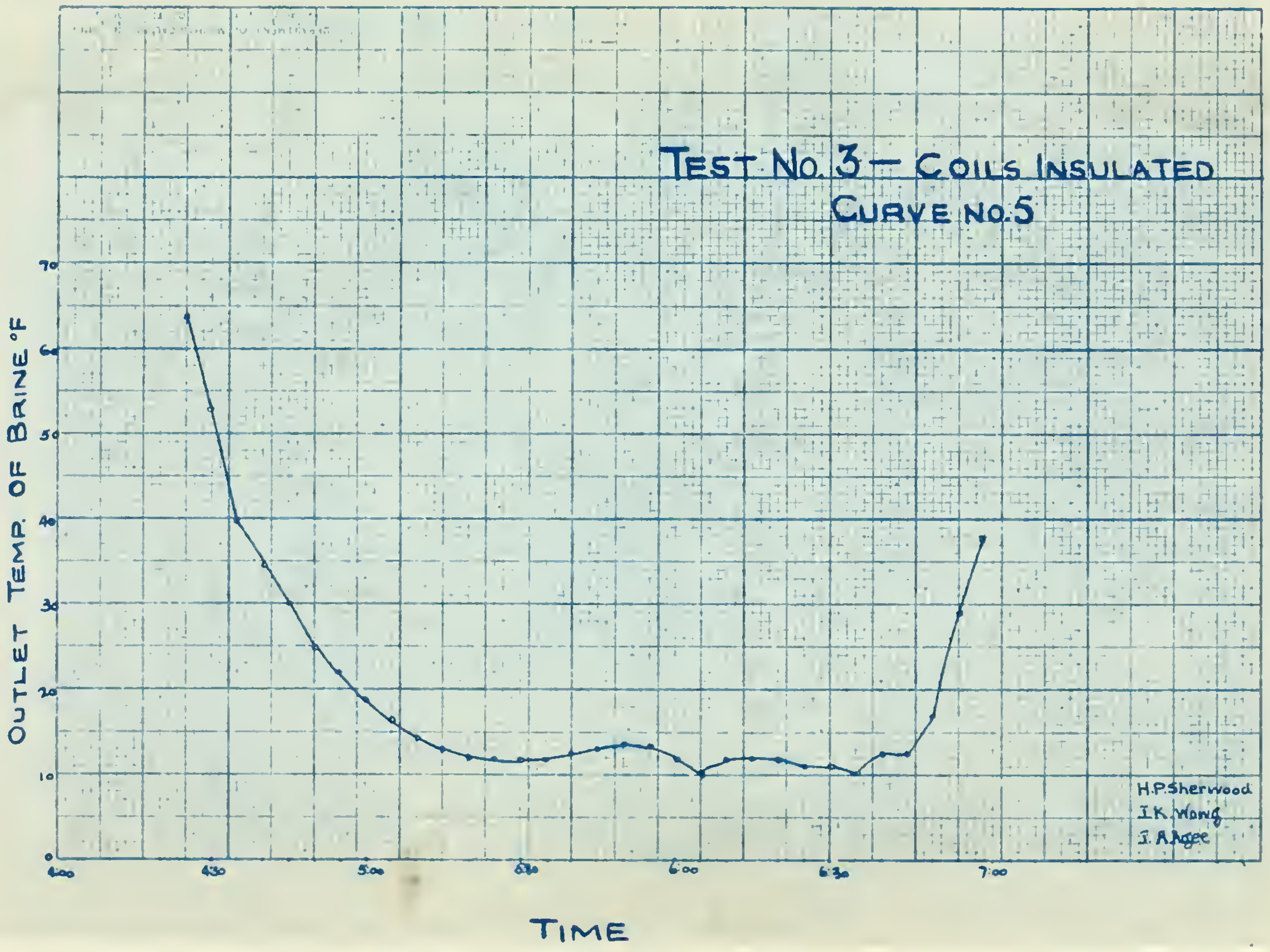


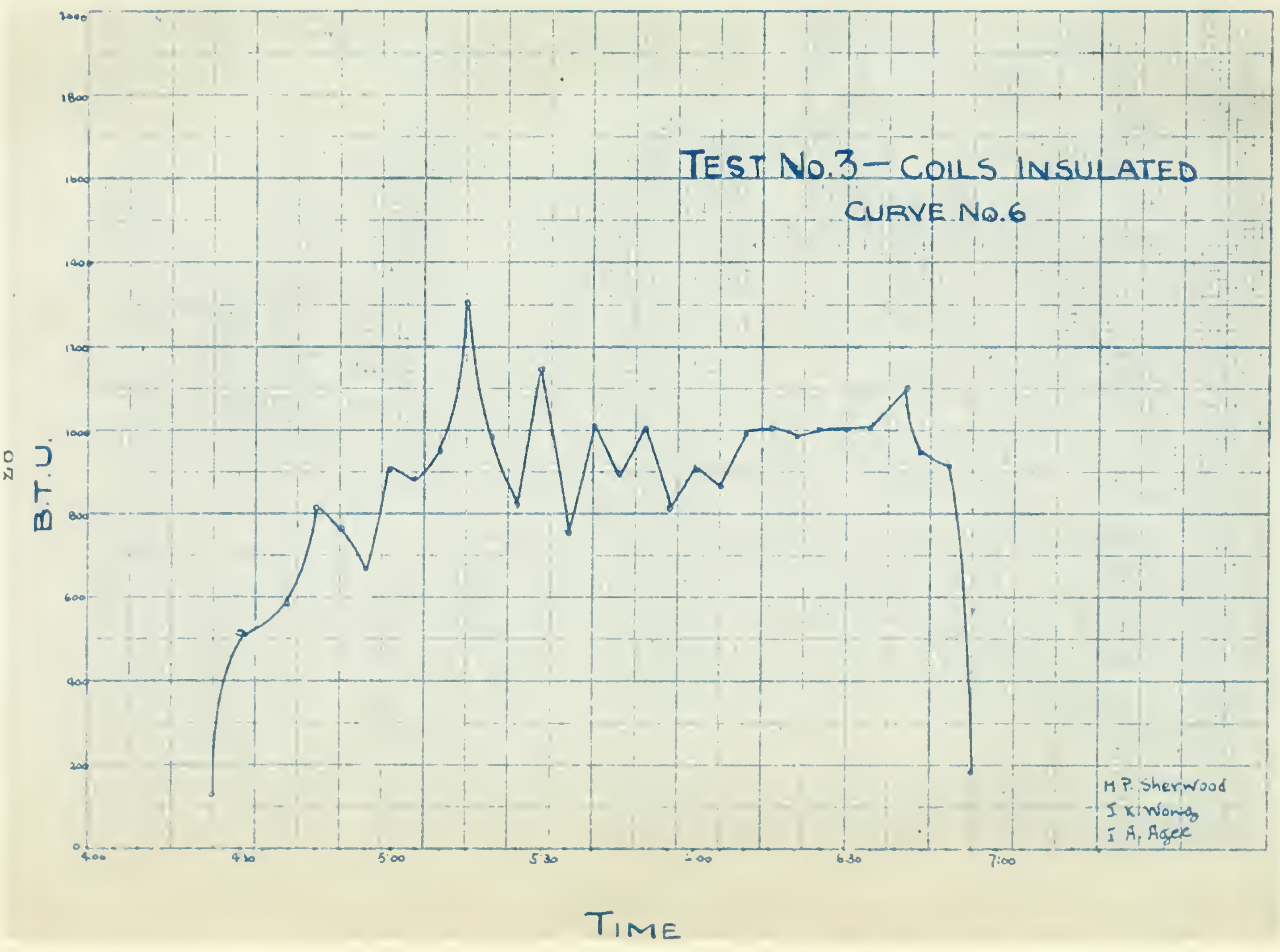
TEST No.1 — COILS NOT INSULATED
CURVE No.1


TEST NO. 1—COILS NOT INSULATED
CURVE No. 2
B.T.U.
TIME
1000
900
800
700
600
500
400
300
200
100
0
9:30
10:00
10:30
11:00
11:30
H.P. Sherwood
J.K. Wong
J.A. Pagel


TEST No. 2 — COILS INSULATED
CURVE No. 3
H.P. Sherwood
J.K. Wong
J.A. Agee
TIME
OUTLET TEMP. OF BRINE °F
0
10
20
30
40
50
60
70
8:30
9:00
9:30
10:00
10:30
11:00
11:30
12:00
12:30
1:00
1:30
2:00

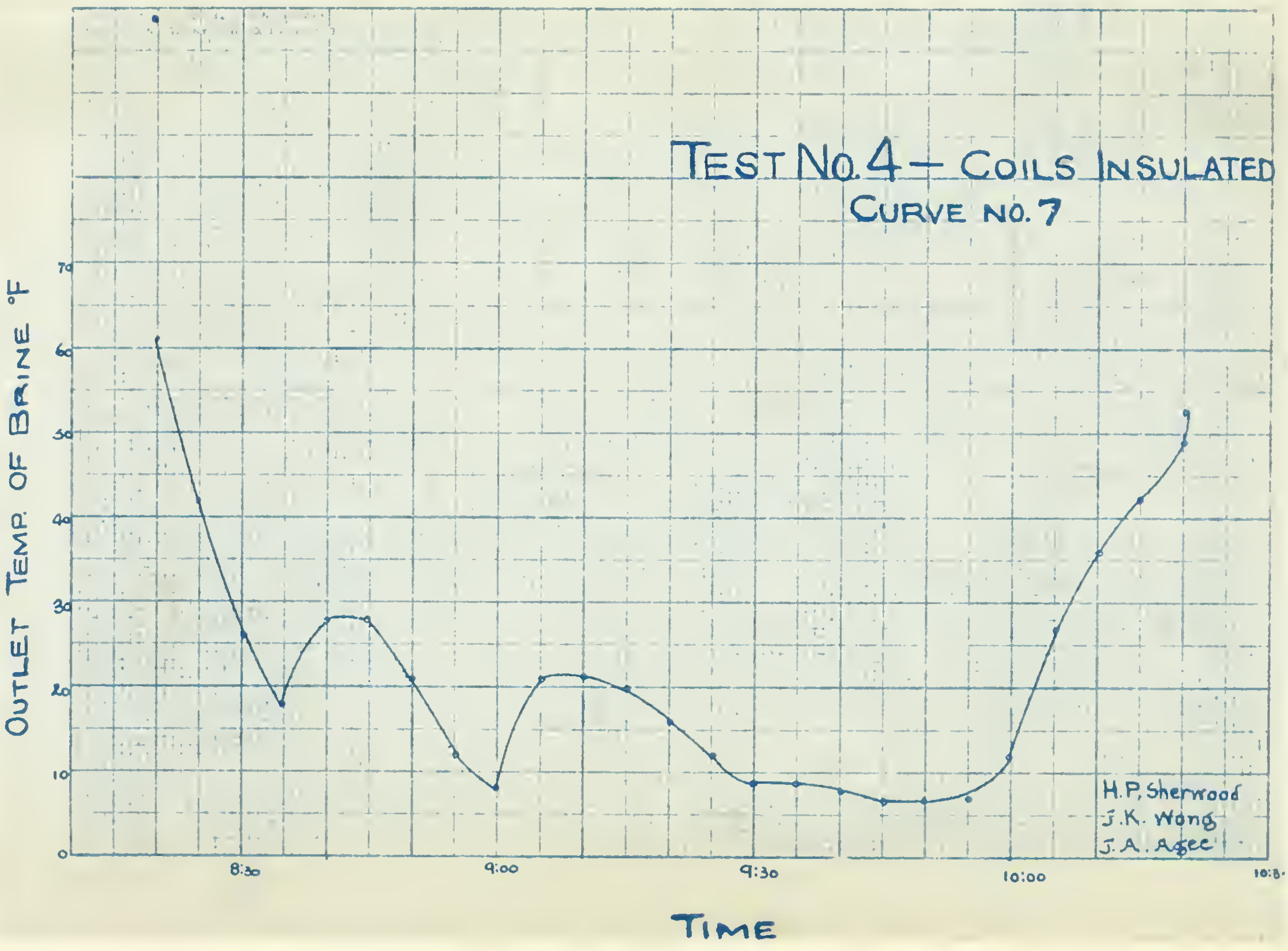

TEST No.2 — COILS INSULATED
CURVE No.4
B.T.U.
800
700
600
500
400
300
200
100
0
8:30
9:00
9:30
10:00
10:30
11:00
11:30
12:00
12:30
1:00
1:30
2:00
H.P. Sherwood.
J.K. Wong
J.A. Agee


TEST NO. 3 — COILS INSULATED
CURVE NO. 5
OUTLET TEMP. OF BRINE °F
70
60
50
40
30
20
10
0
4:00
4:30
5:00
5:30
6:00
6:30
7:00
TIME
H.P. Sherwood
I.K. Wong
J. A. Agee

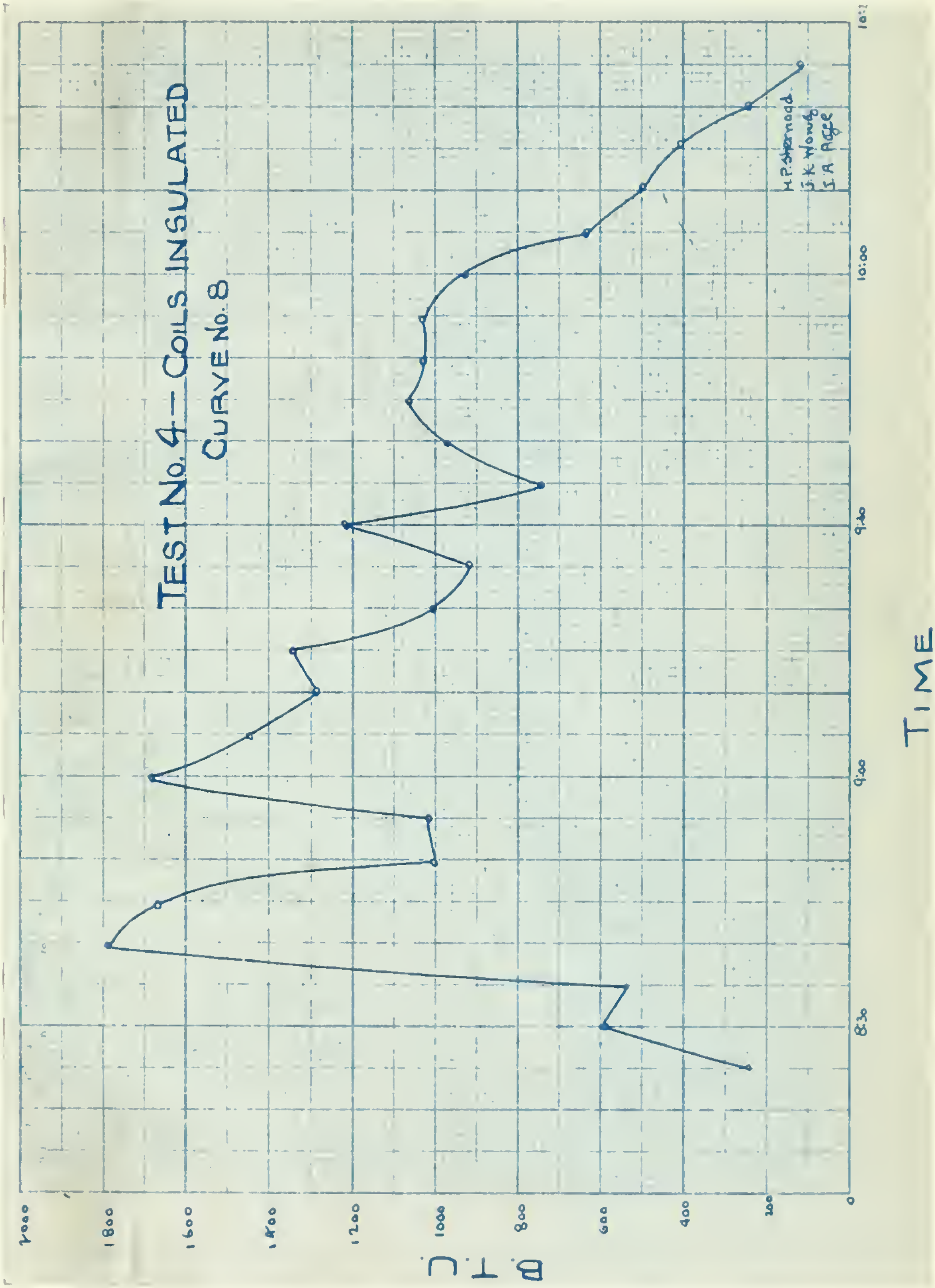


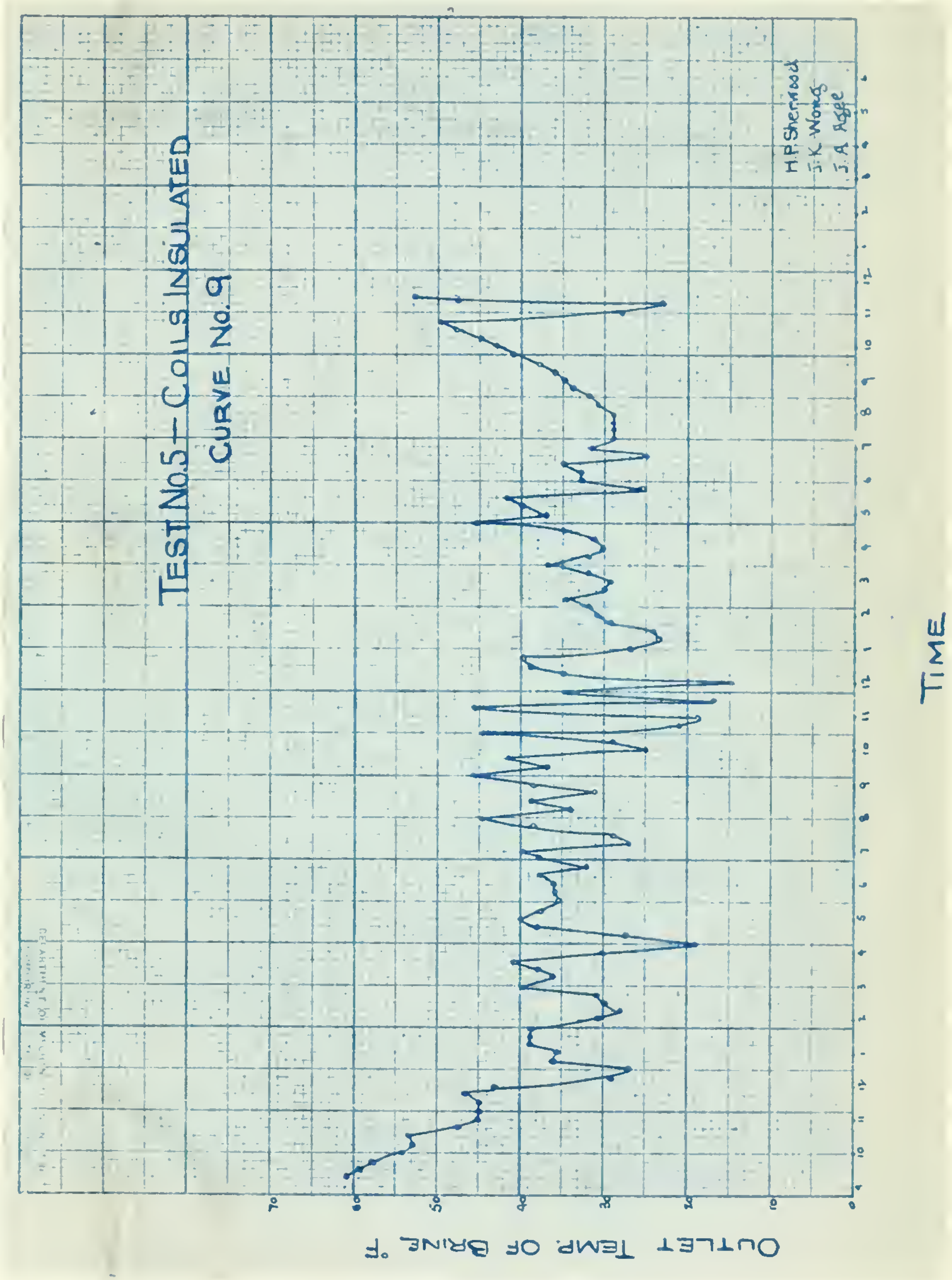
TEST NO. 3 — COILS INSULATED

CURVE NO. 6


TEST NO. 4 – COILS INSULATED
CURVE NO. 7

H. P. Sherwood
J. K. Wong
J. A. Agee

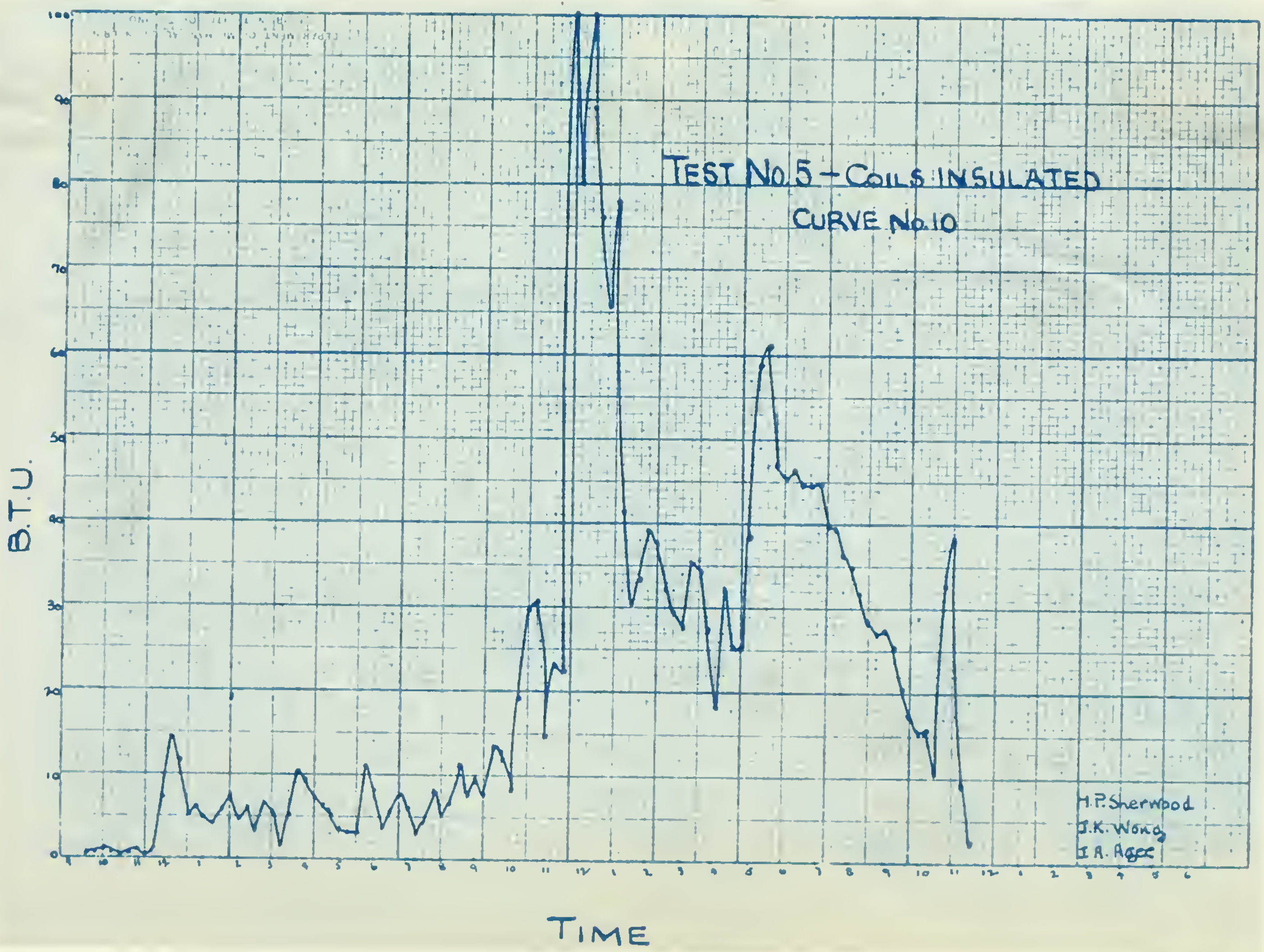

TEST No. 4 — COILS INSULATED
CURVE No. 8
B.T.U.
2000
1800
1600
1400
1200
1000
800
600
400
200
0
8:30
9:00
9:20
10:00
10:2
TIME
H.P. Sherwood
J.K. Wong
J.A. Agee

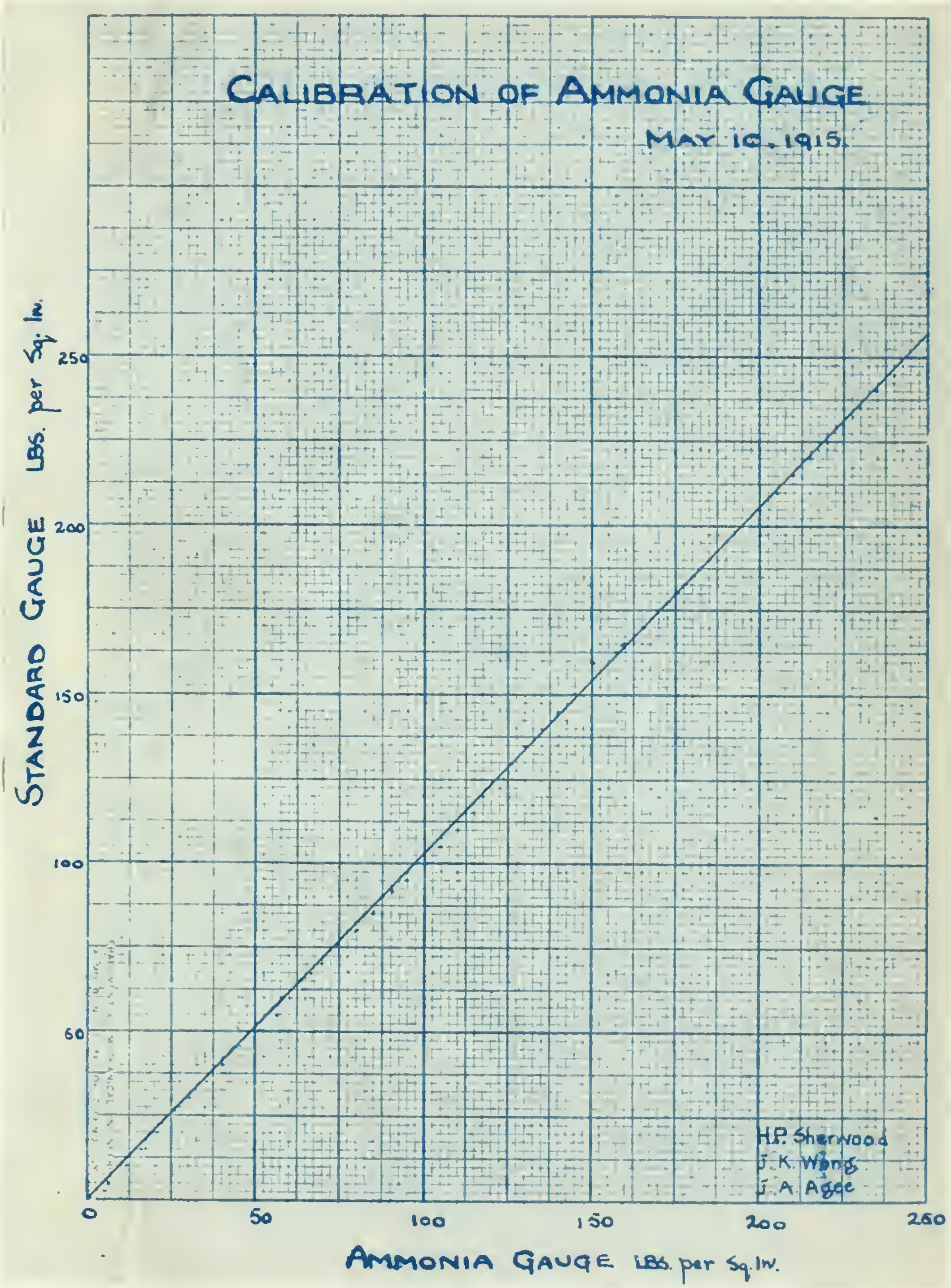


TEST No.5 — COILS INSULATED

CURVE No. 9

H.P. Sherwood
J.K. Wong
J.A. Agee

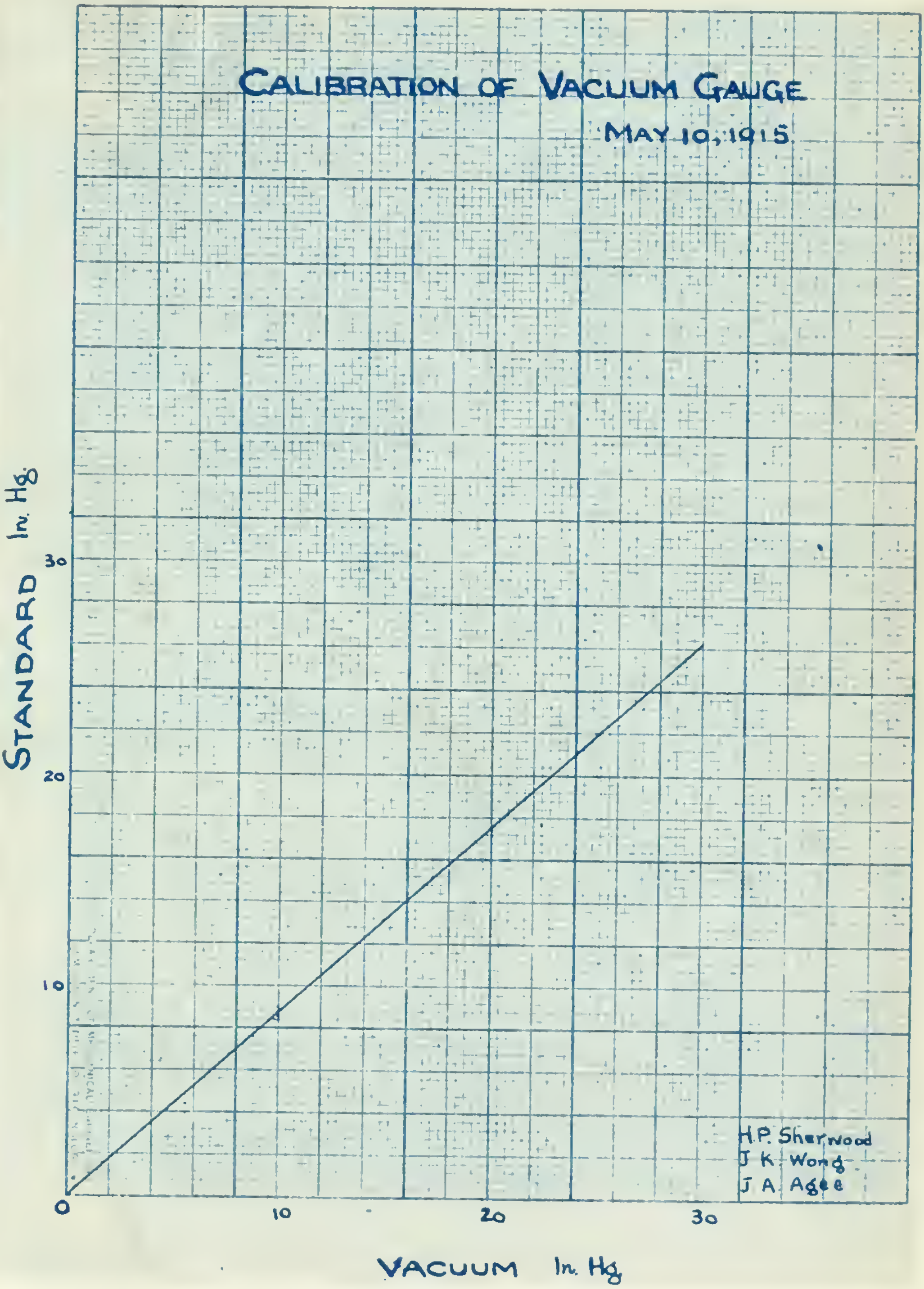

TEST No. 5 – COILS INSULATED
CURVE No. 10
B.T.U.
0
10
20
30
40
50
60
70
80
90
100
TIME
9
10
11
12
1
2
3
4
5
6
7
8
9
10
11
12
1
2
3
4
5
6
7
8
9
10
11
12
1
2
3
4
5
6
H.P. Sherwood
J.K. Wong
J.A. Agee



CALIBRATION OF AMMONIA GAUGE

MAY 10. 1915.

H.P. Sherwood
J. K. Wang
J. A. Agee


CALIBRATION OF VACUUM GAUGE
MAY 10, 1915
STANDARD In. Hg.
VACUUM In. Hg.
0
10
20
30
10
20
30
H.P. Sherwood
J K Wong
J A Agee

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United States Patent Office Paper.

Patent No. 1,122,602